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SPECIFICATIONS

FOR

TRIPLE-EXPANSION

TWIN-SCREW PROPELLING ENGINES,

WITH BOILERS AND AUXILIARY MACHINERY,

FOR

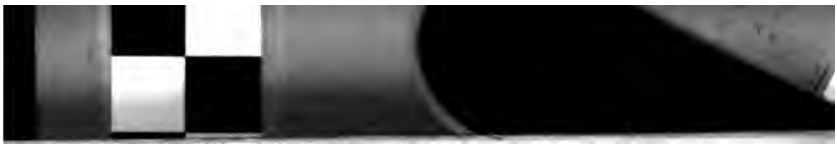
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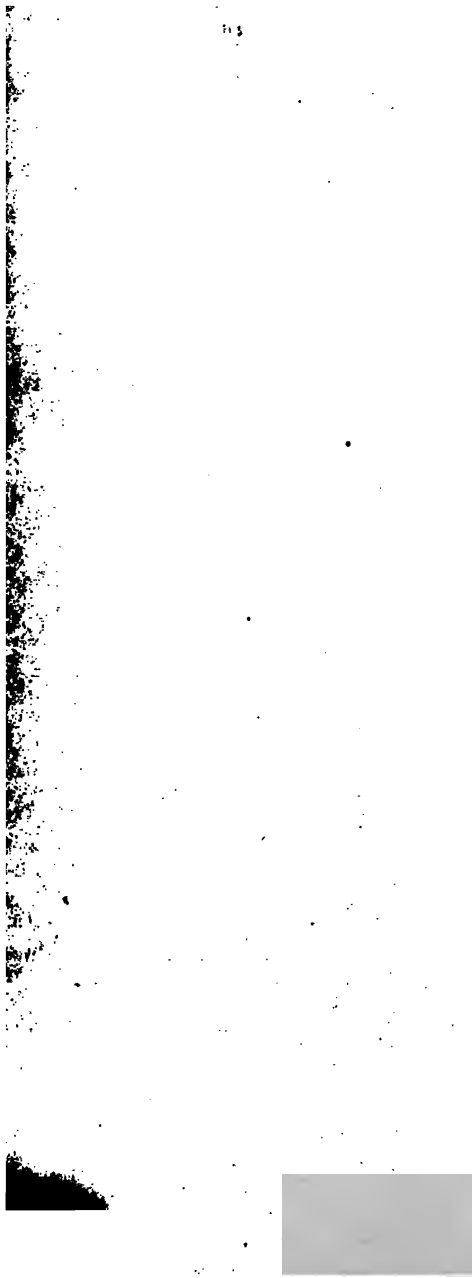
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SPECIFICATIONS

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TRIPLE-EXPANSION

TWIN-SCREW PROPELLING ENGINES,

WITH BOILERS AND AUXILIARY MACHINERY,

FOR

NAVAL ACADEMY PRACTICE VESSEL,

OF ABOUT 800 TONS DISPLACEMENT.

BUREAU OF STEAM ENGINEERING,
NAVY DEPARTMENT,
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LIST OF PLANS ACCOMPANYING THESE SPECIFICATIONS.

Sheet No. 1. General arrangement in fire-room, engine-room, and shaft-alleys.
2. General arrangement of engines.
3. High-pressure cylinders.
4. Intermediate-pressure cylinders.
5. Low-pressure cylinders.
6. Engine-frames and bed-plates.
7. Condenser.
8. Air-pump and engine.
9. Boilers.
10. Valve gear.





INDEX.

A.

Page.

Air-ducts 45
Air-cocks, boiler..... 54
Air-pressure gauges 57
Air-pump 29
Ash-pit doors..... 46
Ash-dumps 57
Ash-hoists 55
Ash-pans..... 47
Ash-sprinklers 57
Attachment of valves to hull.. 67
Auxiliary engine stop-valves. 65
Auxiliary exhaust-pipes 61
Auxiliary feed-pipes..... 62
Auxiliary feed-pumps 55
Auxiliary steam-pipes 60

B.

Bars, grate and bearers..... 44
Bars, lazy..... 47
Bearings, stern-bracket..... 26
Bearings, stern-tube..... 25
Bearings, thrust..... 24
Bed-plates 13
Bilge-injection valve 32
Bilge-suction pipes 34
Bilge-strainers 66
Bleeder-pipes 61
Blow-pipes..... 52
Blow-valves, surface 52
Blower-engines..... 56
Blowers, fire-room 56
Boilers..... 40
Boiler air-cocks..... 54
Boiler attachments 49
Boiler bracing..... 42
Boiler drain-cocks..... 54
Boiler-heads 41

Page.

Boiler stop-valves 50
Boiler man-holes and hand-holes..... 43
Boiler material 40
Boiler protectors, zinc..... 54
Boiler pumping-out pipes..... 52
Boiler-saddles 49
Boiler-shells 41
Boiler-tubes 41
Boiler tube-sheets 41
Boiler water-gauges 53
Bolts and nuts 24
Bottom-blow valves 52
Boxes, journal 23
Bracing, boiler 42
Brasses and caps, crank-shaft. 13
Brasses, crank-pin..... 12
Bridge-walls 44
Bridges, hanging..... 45

C.

Casing, H. P. cylinder..... 4
Casing, intermediate cylinder 4
Casing, L. P. cylinder..... 4
Changes in plans and specifications..... 80
Chests, valve 5
Circulating apparatus..... 54
Circulating-pump 31
Circulating-pump engine..... 31
Circulating-plates 47
Circulating-pump connections 31
Clearances, cylinder..... 5
Clocks 40
Clothing and lagging 68
Cocks and valves 67
Cocks, boiler air..... 54
Cocks, boiler drain 54
Cocks, cylinder drain..... 9





	Page.
Cocks, gauge	53
Combustion-chambers	42
Condenser	27
Connecting-rods	11
Cover, smoke-pipe	49
Covers, cylinder	5
Covers, valve-chest	7
Counters, revolution	38
Crank-pin brasses	12
Crank-shaft brasses and caps	13
Crank-shafts	19
Cross-head guides	14
Cross-heads and gibs, and brasses	11
Cross-heads and guides, valve-stem	16
Cylinder clearances	5
Cylinder covers	5
Cylinder drain-cocks	9
Cylinder relief-valves	9
Cylinders	3
Cylinders, pump	65

D.

Desk, engine-room	40
Distilling apparatus	58
Doors, ash-pit	46
Doors, furnace	45
Doors, uptake	47
Drain-cocks, boiler	54
Drain-cocks, cylinder	9
Drain-pipes and traps	64
Drawings of completed machinery	79
Drawings, working	79
Dry-pipes	50
Ducts, air	45
Duplicate pieces	73

E.

Eccentrics	14
Eccentric-rods	15
Eccentric-straps	15
Engine-frames	12
Engine-indicators	39
Engine-room auxiliary pump	35
Engine-room desk	40
Engine-room telegraphs	38
Engine-room water-service	35
Engine throttle-valves	10
Engines, turning, and gear	36
Escape-pipe	62
Exhaust-pipes	18
Exhaust-pipes, auxiliary	61

F.

Fans, ventilating	40
Feed-check valves	50
Feed-pump, auxiliary	55
Feed-pump, main	54
Feed-pump pressure-gauges	55
Feed-tank	32
Feed-tank suction-pipes	33
Feed-water heater	55
Fire and bilge-pump	35
Fire-main	62
Fire-room blowers	56
Fire-tool racks	57
Floors and platforms	70
Furnaces	44
Furnace-doors	45
Furnace-fronts	45

G.

Gauge-cocks	53
Gauges, air-pressure	57
Gauges, boiler water	53
Gauges, feed-pump pressure	55
Gauges, steam	53
Gear for working valves from deck	71
General description	1
Grate-bars and bearers	44

H.

Hand-rails	71
Hand-holes and man-holes, boiler	43
Hanging-bridges	45





Page.

Heads, boiler 41
Heater, feed-water 55
Hose and hose-reels 69
High-pressure cylinder casings 4

I.

Indicators, engine 39
Indicators, revolution 38
Inspection 80
Intermediate and low-pressure steam-pipes 61
Intermediate-cylinder casings. 4

J.

Jacks for coupling-bolts 25
Journal-boxes 23

L.

Labels on gear and instruments 68
Ladders 70
Lazy-bars 47
Lifting-gear 71
Link-blocks 16
Links, main 16
Links, suspension 16
Linings, valve-chest 6
Low-pressure cylinder casings 4
Low-pressure slide-valves 8
Lubrication 21

M.

Man-holes and hand-holes, boiler 43
Mandrels for white-metal bearings 23
Main feed-pipes 62
Main feed-pump 54
Main feed-pump exhaust 62
Main links 16
Main steam-pipes 60
Materials and workmanship .. 75
Material, boiler 40

Page.

Material, tests of 77
Material and fitting of pipes.. 65

N.

Nuts and bolts 24

O.

Oil-drips 23
Oil-tanks 72
Omissions 80
Outboard-delivery valve 32

P.

Painting 77
Pipe, escape 62
Pipe, smoke 48
Pipes, auxiliary feed 62
Pipes, auxiliary steam 60
Pipes, bilge-suction 34
Pipes, bleeder 61
Pipes, blow 52
Pipes, boiler pumping-out 52
Pipes, drain, and traps 64
Pipes, dry 50
Pipes, exhaust 18
Pipes, feed-tank suction 33
Pipes, intermediate and low-pressure steam 61
Pipes, material and fitting of. 65
Pipes, main feed 62
Pipes, main steam 60
Pipes, sea-suction 34
Pipes, thickness of 64
Pipes through coal-bunkers .. 63
Pipes through water-tight bulkheads and decks 63
Pistons 10
Piston-rod stuffing-boxes 10
Piston-rods 11
Piston-valves 7
Platforms, floors and 70
Preliminary tests and trials... 78
Propellers, screw 26
Propeller-shafts 20





	Page.
Pump-cylinders	65
Pump relief-valves	66
Pump, air	29
Pump, auxiliary feed	55
Pump, circulating	31
Pump, circulating, engine	31
Pump, engine-room auxiliary	35
Pump, fire and bilge	35
Pump, main feed	54

R.

Record of weights	78
Revolution-counters	38
Revolution-indicators	38
Reversing-gear	17
Reversing-shaft bearings	18
Reversing-shafts	18
Riveted joints	43

S.

Safety-valves	51
Salinometer-pots	53
Screw-propellers	26
Sea-injection valves	32
Sea-suction pipes	34
Sea-valves	66
Securing engines in vessel	36
Sentinel-valves	52
Shells, boiler	41
Shafts	19
Shafts, crank	19
Shafts, propeller	20
Shafts, thrust	20
Shafts through bulkheads	70
Slide-valves, low-pressure	8
Smoke-pipe	48
Smoke-pipe cover	49
Speaking-tubes	38
Specifications and plans, changes in	80
Steam and vacuum-gauges	37
Steam-gauges	53
Steam-tube cleaners	57
Stern-bracket bearings	26
Stern-tube bearings	25
Stern-tube stuffing-boxes	25
Stuffing-boxes	23
Stuffing-boxes, piston-rod	10
Stuffing-boxes, stern-tube	25
Stuffing-boxes, valve-stem	10
Suction-pipes from bottoms of condensers	33
Superintending engineer's office	78
Surface blow-valves	52
Suspension-links	16

T.

Tank, feed	32
Tanks, oil	72
Telegraphs, engine-room	38
Tests and trials, preliminary	78
Tests of boilers and machinery	77
Tests of material	77
Thermometers	37
Thickness of pipes	64
Throttle-valves, engine	10
Thrust-bearings	24
Thrust-shafts	20
Tools	73
Traps and drain-pipes	64
Tubes, boiler	41
Tube-cleaners, steam	57
Tube-sheets, boiler	53
Turning-engines and gear	36

U.

Uptakes	47
Uptake-doors	47

V.

Vacuum-gauges, steam and	37
Valve-chests	5
Valve-chest covers	7
Valve-chest linings	6
Valve-gear	14
Valve-stems	8
Valve-stem stuffing-boxes	10
Valve-stem cross-heads and guides	16
Valves, cocks and	67





SPECIFICATIONS

FOR

Vertical Twin-Screw Triple-Expansion Engines,

WITH

BOILERS AND AUXILIARY MACHINERY,

FOR

NAVAL ACADEMY PRACTICE-VESSEL,

OF ABOUT 800 TONS DISPLACEMENT.

REFERENCE BEING HAD TO THE DRAWINGS ACCOMPANYING AND FORMING PART OF THESE SPECIFICATIONS.

1. GENERAL DESCRIPTION.

The propelling engines will be rights and lefts, placed in a common water-tight compartment. These engines will be of the vertical, inverted-cylinder, direct-acting, triple-expansion type, each with a high-pressure cylinder 13½ inches, an intermediate-pressure cylinder 21 inches, and a low-pressure cylinder 31 inches in diameter; the stroke of all pistons being 20 inches. It is estimated that the collective indicated horse-power of propelling, air-pump, and circulating-pump engines should be about 1,300 when the main engines are making about 240 revolutions per minute. The high-pressure cylinder of each engine will be forward and the low-pressure cylinder aft. The main valves will be of





the piston type for the high-pressure and intermediate-pressure cylinders, and slide-valves for the low-pressure cylinders, all worked by Stephenson link-motions with double-bar links. The piston-valves, valve-liners, and valve-gear will be made interchangeable, as hereinafter specified. There will be one piston-valve for each high-pressure cylinder, two for each intermediate-pressure cylinder, and one slide-valve for each low-pressure cylinder. Each main piston will have one piston-rod, with a cross-head working on a bar-guide. The framing of the engines will consist of wrought-steel columns, trussed by wrought-steel stays. The engine bed-plates will be of cast-steel, supported on wrought-steel keelson-plates built in the vessel. The crank-shafts will be made in three interchangeable sections. All shafting will be hollow. The shafts, piston-rods, connecting-rods, and working parts generally will be forged of mild open-hearth steel.

The condensers will be made entirely of composition. The main condenser will have a cooling surface of about 1,820 square feet, measured on the outside of the tubes, the water passing through the tubes. There will be a double, vertical, single-acting air-pump worked by a vertical compound engine. The circulating-pump will be of the centrifugal type, worked independently. The propellers will be right and left, of manganese bronze, or approved equivalent metal.

There will be an auxiliary condenser of sufficient capacity for the auxiliary machinery. The auxiliary condenser will have a combined air and circulating-pump.

There will be two straight-way fire tubular boilers, placed in a common water-tight compartment, as shown.

The outside diameter of boilers will be about 8 feet 9½ inches, and the length about 17 feet over heads.

They will be constructed for a working pressure of 160 pounds per square inch.

Each of the boilers will have two corrugated furnace-flues 3 feet 3 inches internal diameter.

The total heating surface will be about 2640 square feet, measuring the tubes on the outer surface, and the





grate surface 78 square feet. There will be a main feed-pump in the fire-room and an auxiliary feed-pump in the engine-room. The main feed-pump will connect with a main feed-pipe, and will have a capacity sufficient to supply twice the amount of water necessary for the boilers when steaming at full power under forced draft. There will be a smoke-pipe located as shown.

The forced-draft system will consist of two blowers, which will discharge into main air-ducts under the fire-room floor, from which a branch duct will lead to the ash-pit of each furnace. Means will be provided for closing the ash-pits when under forced draft and for preventing leakage of gases out of the furnace-doors. The draft to each furnace will be regulated by means of a damper.

There will be steam reversing-gear, an ash-hoist, a turning-engine, auxiliary pump, an engine-room ventilating-fan, engine for driving workshop machinery, a distilling apparatus, and such other auxiliary or supplementary machinery, tools, instruments, or apparatus as are described in the following detailed specifications or shown in the accompanying drawings.

2. CYLINDERS.

They will consist of casings of best quality of cast-iron as hard as can be properly worked, with working-linings for all the piston-valves. The cylinder casings will include the valve-chests, steam-ports and passages, the lower heads, and the various brackets to which the cylinder supports will be attached. The steam and exhaust-ports will be smoothly cored to the dimensions shown in drawings, the walls of the passages being strongly stayed by ribs.

The flanges for securing the cylinders to each other will be so faced that when bolted together the centers of the cylinders will be 2 feet 7½ inches apart, with the cylinder-axes all in one plane and parallel. The cylinder casings will be bolted together and to their supporting columns by body-bound steel bolts. They will be bored to their respective diameters when in a vertical position.





3. HIGH-PRESSURE CYLINDER CASINGS.

The head will be cast with a single wall and the barrel will be ⅞ inch thick. It will be faced and bored, as shown, for the reception of the valve-chest linings. It will be bored to a diameter of 13½ inches, the boring being done in a vertical position. It will be counterbored at both ends, leaving the working bore 20½ inches long. The brackets at the bottom for attachment of the supporting columns will be well ribbed and truly bored or faced for the columns as shown. There will be flanges for bolting to the intermediate-pressure cylinder, these being faced to a plane parallel to the axis of the cylinder. The walls of the steam passages will be properly stayed. There will be facings, flanged and ribbed where necessary, for the attachment of the cylinder and valve-chest covers, steam-pipe, exhaust-pipe, piston-rod stuffing-box, relief-valves, drain-cocks, indicator-pipes, drain-pipes, and oil-cups.

4. INTERMEDIATE-PRESSURE CYLINDER CASINGS.

They will be of close-grained cast-iron as hard as can be properly worked. Each will have two piston-valves. Each will be bored to a diameter of 21 inches, the boring being done in a vertical position. The cylinders will be counterbored at both ends, leaving the working bore 20½ inches long. Each will have faced flanges for bolting to the high and low-pressure cylinders. The barrels of the casings will be ⅞ inch thick. There will be brackets well ribbed and truly bored or faced for the supporting columns as shown, also facings for steam and exhaust pipes, receiver safety-valves, receiver live-steam pipes, piston-rod stuffing-boxes, drain-cocks, indicator-cocks, drain-pipes, and oil-cups. There will also be faced flanges for bolting the high-pressure and intermediate-pressure cylinders together.

5. LOW-PRESSURE CYLINDER CASINGS.

Each will be of the same material as the intermediate-pressure casing, and will be similary fitted, with the following exceptions: It will have a slide-valve. It will





have a flange on the forward side for bolting to the intermediate-pressure cylinder. It will be bored to a diameter of 31 inches, the boring being done in a vertical position. The cylinders will be counterbored at both ends, leaving a working bore 20½ inches long.

6. CYLINDER COVERS.

They will be of cast-steel, and cast with single walls ⅝ inch thick, well stiffened by ribs ⅜ inch thick on high-pressure, ½ inch thick on the intermediate-pressure, and ⅝ inch thick on the low-pressure covers. They will be so formed as to leave as little clearance as practicable.

Each cover will be turned and faced to fit its cylinder casing, and finished on outside of flanges.

The cover of the high-pressure cylinder will be secured to the cylinder casing by twelve ⅞-inch steel studs, the cover of the intermediate by sixteen ⅞-inch steel studs, and the low-pressure cover by twenty ⅞-inch steel studs.

Holes will be drilled and tapped for jack-bolts and eye-bolts.

7. CYLINDER CLEARANCES.

Care will be taken that the clearances in the cylinders are made no larger than absolutely necessary. After the engines are set up in place and connected, the volume of the clearance at each end of each cylinder will be carefully measured by filling the space with water or oil, and the result plainly marked on some conspicuous part of the cylinder casing. Marks will also be made on the cross-head guides showing the position of the pistons where the clearances were measured.

8. VALVE-CHESTS.

The valve-chests of each high-pressure cylinder will be fitted for one piston-valve, each intermediate-pressure for two, and each low-pressure for a double-ported slide-valve.





There will be openings at each end of the piston-valve chests for inserting and removing the valves and working-linings. These chests will be accurately bored and faced for the reception of the working-linings.

Before the insertion of the linings the steam and exhaust passages must be thoroughly cleaned out and pickled, and care taken that the passages are nowhere contracted to less than the specified areas. There will be an opening on the side of the low-pressure valve-chest for inserting and removing the valve, and the seat must be accurately faced for the valve.

The top of the low-pressure valve-chest is cast with an opening and a flange to receive a stuffing-box for metallic packing. A hood connected with the condenser is bolted on top as shown.

There will be a casing on top of rod, passing through the stuffing-box, and constituting the balancing piston for the weight of the valve.

Each intermediate and low-pressure valve-chest will have a 1½-inch adjustable-spring safety-valve of approved pattern.

All valve-chests will also be fitted with suitable composition drain-cocks or valves that may be operated from the working-platform, the valves to discharge through pipes into the bilge and feed-tank, with the necessary valves for directing the water to either.

9. VALVE-CHEST LININGS.

There will be a working-lining at each end of each valve-chest for each piston-valve. They will be of cast-steel or close-grained cast-iron as hard as can be properly worked, accurately turned and faced to fit the casings, and accurately bored to an internal diameter of 6 inches, leaving the walls ½ inch thick.

They will be forced into place, making all joints perfectly tight, and secured by screws tapped half into the linings and half into the casings.

The valve-chest linings are interchangeable.





The steam-ports of the high and intermediate-pressure cylinders will be 1½ inches wide, those of the low-pressure cylinders will be $1\frac{17}{32}$ inches wide.

The steam-ports in the high-pressure and intermediate-pressure valve-chest liners will have alternating right and left diagonal bridges, taking up not more than one-quarter of the total port area.

The edges of all ports will be finished to a uniform outline.

10. VALVE-CHEST COVERS.

They will be made of cast-steel, the low-pressure cover being ribbed as shown.

The flanges will be turned and faced to fit the openings in, and flanges of valve-chests. The high-pressure and intermediate-pressure covers will be finished on the outside, and the low-pressure covers will have the outside and edges of flanges finished. Each lower cover will be faced and bored to receive the valve-stem stuffing-box.

There will be approved provision for proper oiling of the valve-stems.

The lower covers will have the necessary faces for securing the valve-stem crosshead-guides.

Each high-pressure and intermediate-pressure valve-chest cover will be secured by eight $\frac{5}{8}$-inch and each low-pressure valve-chest cover will be secured by twenty-four $\frac{7}{8}$-inch steel studs, with finished wrought-iron nuts.

The high-pressure and intermediate-pressure valve-chest covers will be interchangeable at the top and at the bottom respectively.

11. PISTON-VALVES.

All the piston-valves will be made in two parts. They will be of cast-iron, as hard as can be properly worked, of a general thickness of $\frac{3}{8}$ inch. Each of these parts will consist of a hollow piston 6 inches in diameter, and will fit the valve-liners accurately without packing-rings.

The high and intermediate-pressure valves will be exactly alike.





The two parts of each valve will be separated, when in place on their valve-stem, by a cast-steel distance-piece, which will be of such length as to make the steam and exhaust laps as follows:

Steam lap—top, 1 inch; bottom, $\frac{29}{32}$ inch.

Exhaust lap—top, minus $\frac{1}{8}$ inch; bottom, $\frac{7}{32}$ inch.

2. LOW-PRESSURE SLIDE-VALVES.

They will be double-ported, and will be made of cast-iron. The face of the valve will be finished to a true plane. All the edges will be finished.

The weight of the valve will be balanced as shown in drawings.

The steam lap will be—top, 1 inch; bottom, $\frac{29}{32}$ inch.

The exhaust lap will be—top, $\frac{5}{64}$ inch; bottom, $\frac{15}{32}$ inch.

3. VALVE-STEMS.

They will be of forged-steel. The high-pressure and intermediate-pressure will be 1¼ inches in diameter at the stuffing-boxes and reduced to 1 inch where they pass through the valves, the low-pressure being 1¾ inches in diameter at the stuffing-box and reduced to 1⅜ inches where it passes through the valve. The lower end of each intermediate-pressure stem will have a shoulder and thread cut on it and be fitted with a steel nut for securing it to the cross-head. A slot will be cut in the thread on each stem and fitted to a feather in the cross-head. The nuts will have collars recessed in counterbores in the cross-heads and will be secured by set-screws. The thread on each stem must be sufficiently long to allow a reasonable latitude of adjustment. The high-pressure and low-pressure valve-stems take hold directly of the link-blocks.

The low-pressure valve-stem will have a cast-steel casing at top secured as shown. This casing is the balancing piston, and works in a stuffing-box with metallic packing.

A split-pin will be put through the valve-stem to keep the nuts from coming off.





14. CYLINDER RELIEF-VALVES.

There will be a 1½-inch adjustable-spring relief-valve on each end of each main cylinder. The valves and their casings will be of composition. Pipes will lead from the relief-valves to the bilge with easily-broken joints.

These valves will have nickel seats or their equivalent, and the valve-fittings will be so constructed that the valves can be easily overhauled without slacking the springs and so that steam will not come into contact with the springs. The springs will have approved means of adjustment, and will be long enough to allow the valves to open to their full extent without unduly increasing the load. The valves will be guided by loosely-fitting wings. The springs will bear on shoulders on spindles which fit loosely in sockets recessed in the backs of the valves. These spindles will be so fitted that the valves can be moved by the application of a lever. The valves will be fitted with casings, which will prevent danger of people being scalded by hot water from the cylinders. Suitable fulcrums will be on casings for the application of levers for working the valves; one lever to be furnished for each engine. All springs must pass a satisfactory test.

15. CYLINDER DRAIN-COCKS.

Each cylinder will be fitted with an approved drain-cock, placed so as to drain the cylinder thoroughly. The cocks must be perfectly tight without undue friction. The drain-cock of each cylinder of each engine will be worked by a single lever at the working-platform. All the drain-cocks of each engine will discharge into a pipe leading to the fresh-water side of the condenser, with a branch to the bilge. This pipe will have a stop-valve near the condenser, and will have a spring non-return valve, without hand-gear, which can open to the bilge-discharge when the drain to condenser is closed, but which will prevent air entering the condenser at any time. Small drain-cocks will be fitted to the lowest parts of drain-pipes.



16. ENGINE THROTTLE-VALVES.

Each engine will have a throttle-valve in the main steam-pipe as near as possible to the high-pressure cylinder. This throttle will have a locking-gear, worked from the platform, which will hold the valve wide open when desired.

The throttle will be worked by a screw-stem, the gear operating the stem being worked by a 10-inch hand-wheel at the platform, where it will have an index divided as directed.

The spindles will be horizontal. The valves, stems, and casings will be of composition.

17. PISTON-ROD STUFFING-BOXES.

They will be made of composition, and fitted with approved metallic packing with efficient means of lubrication. The packing of each stuffing-box will be made in two independent sections, so that in case of injury to one section the other alone will make a tight joint; this packing to be in all respects equal to Watson's.

18. VALVE-STEM STUFFING-BOXES.

They will be similar to the piston-rod stuffing-boxes.

19. PISTONS.

They will be of cast-steel or approved bronze, and will be dished.

Each piston will have one packing-ring, 1 inch wide, of hard cast-iron, cut obliquely and tongued. The thickness of the packing-rings is ½ inch for the high-pressure, ¾ inch for the intermediate pressure, and 1 inch for the low-pressure piston.

The packing-rings will be sprung into position.

There will be sufficient clearance between the piston and cylinder to allow for difference of expansion.





When completed the pistons must be carefully weighed, and no excess of weight will be allowed over that due to the dimensions shown in the drawings.

20. PISTON-RODS.

The piston-rods will be of forged steel, 2½ inches diameter, excepting at ends, where they will be 2¼ inches diameter over threads. They will be turned to fit the pistons, with collars, as shown, and fitted each with a composition nut at the piston end secured by a screwed stop-pin. The nut at the cross-head end will be secured by a set-screw. The parallel parts will be smoothly and accurately turned.

Each piston-rod will have, at its seating in the piston, a collar 3½ inches diameter and ¾ inch thick, well filleted, and recessed in the piston as shown.

They will be kept from turning in the pistons and cross-heads by stop-pins.

21. CROSS-HEADS AND GIBS, AND BRASSES.

The cross-heads will be of cast-steel. The cross-head pins will be conically cored.

The gibs will be prevented from moving up or down on the cross-heads by lips, and will be firmly held to the cross-heads by bolts passing through the shoes and tapped into the gibs.

The gibs will be of composition lined with white-metal. Their bearing-surface will be 9 inches long and 8 inches wide.

22. CONNECTING-RODS.

The connecting-rods, with their bolts, will be of forged steel, finished all over. The caps will be of composition.

The connecting-rods will be 40 inches long between centers, turned 2½ inches in diameter at small end and 4 inches at large end, the sides being faced off to a uniform thickness of 2½ inches.

The cross-head end of each rod will be forked to span the cross-head pins. The brasses will be bored to 3¼





inches diameter to fit pins. Each of the caps will be secured by two 1¼-inch bolts.

The crank-pin end of each connecting-rod will be increased in thickness to 4 inches, faced on each side, and bored 8 inches in diameter for the brasses. The caps will be 2⅛ inches thick at the crown, each to conform to the shape of the connecting-rod end, and will be lined with white-metal and properly channeled for oiling; the bolts will be 1⅝ inches in diameter; the heads to be fitted with stop-pins and the upper ends of bolts to be provided with split-pins of ample size outside the nuts. The nuts will be of wrought-iron, each with a collar recessed into the connecting-rod head and secured by a set-screw. The cap-bolts will pass partly through the butt brasses.

In the lower jaw of each connecting-rod two bolts will be fitted, passing through the metal of the rods, and tapped into the corresponding lip of the brasses to prevent closing in when heated, each of these bolts being secured by a set-screw.

Composition distance-pieces will be fitted between the connecting-rods and caps; they will be so fitted as to be removable without taking out the cap-bolts, and will be channeled so as to be easily reduced when taking up lost motion.

The caps will each be fitted with two eye-bolts for handling.

23. CRANK-PIN BRASSES.

They will be accurately fitted to the connecting-rods and secured as before specified. They will be fitted with approved white-metal in strips, accurately fitted to the crank-pins, and properly fitted for distribution of oil. They will be 1 inch thick, including white-metal, and faced with sufficient clearance between crank-webs to prevent nipping when heated.

24. ENGINE-FRAMES.

Each cylinder will be supported by three wrought-steel columns, except the low-pressure cylinders, which will have four, as shown in the drawings.





All the feet of the columns will be faced to fit the planed faces or holes provided for them on the cylinders and the bed-plates.

The columns will be stiffened by steel tie-rods, as shown. The lower end of the cross-head guides will take hold of a bracket secured to columns.

5. BED-PLATES.

They will consist, each, of three steel castings, flanged and bolted together, as shown.

The upper and lower flanges will be connected and properly stiffened by ribs, as shown.

The bed-plates will be secured to the engine-seatings by ¾-inch bolts through the lower flange, as shown in drawing, and they will be properly finished and faced for crank-shaft brasses and caps and for the flanges of the supporting columns. Each jaw will be fitted with an adjustable composition chock for the vertical alignment of the shaft. The bed-plates will have facings for the reversing and turning engine, as may be required.

6. CRANK-SHAFT BRASSES AND CAPS.

The bottom brass for each bearing will be cylindrical, lined with approved white-metal, fitted with ample oil-channels. The cap will be of composition, lined with white-metal, and fitted with ample oil-channels. The bottom brass and cap will be faced 5½ inches long for all the journals, turned and finished to fit the jaws of bed-plate and chock, as shown, and accurately bored to fit the journals of shaft. The chock will be of composition. Provision will be made for circulating water around the butt-brasses. Each cap will have an oval hand-hole for the purpose of feeling the journal. This hand-hole will have a cover, with handle—the lower part of the cover being formed into a perforated tallow-box, reaching to within a quarter of an inch of the journal.

The cap-bolts will be of forged steel, 1⅜ inches in diameter, each provided with a collar, as shown. One end of each bolt will be threaded and screwed into the engine





bed-plate. The other end will be threaded and fitted with finished wrought-iron collar-nut and set-screw—the part beyond the nuts will be squared and each fitted with a split-pin.

The caps and brasses will be tapped and fitted with eye-bolts for handling.

The brasses will be separated by channeled brass distance-pieces.

After the engines are secured in the vessel the brasses will be bored out in place to perfect alignment, if required. They will also be tried on their shafts and any defects made good by scraping to a proper bearing.

The brasses will be so fitted that the only bearing of the journals will be on the surface of the white-metal.

7. CROSS-HEAD GUIDES.

The cross-head guide will consist of a cast-steel bar, cored for water circulation, and faced with cast-iron on the go-ahead side. When backing the wearing surface will be on the cast-steel bar. It will be bolted to the cylinder at the top, and to a bracket carried by the columns at the bottom.

All parts of the guide will be smoothly and accurately finished all over, excepting the core made for water circulation.

Brass oil-boxes will be provided for supplying oil at both ends of guide.

8. VALVE-GEAR.

It will be of the Stephenson type, with double-bar links. All valves will be worked direct. There will be one cross-head for the intermediate-pressure valve-stems. All parts of the valve-gear will be interchangeable.

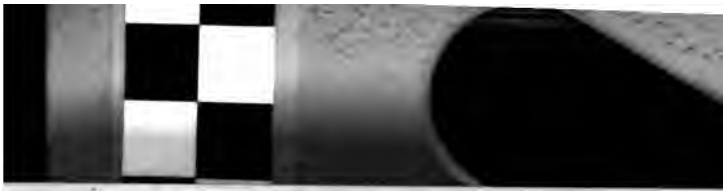
The valve-gear will be so adjusted that the mean cut-off in full gear for both ends of each cylinder will be at 0.7 stroke.

9. ECCENTRICS.

They will be of cast-steel, each in two parts.

The two parts of each eccentric will be neatly fitted together and secured by two steel bolts. They will be





bored out to a snug fit on the crank-shaft couplings and turned accurately on the outside to an eccentricity of 2 inches, and will be recessed at each side for the flanges of the eccentric-straps. The high-pressure eccentric seating will consist of the forward coupling-disk, with a disk bolted to it to give it the necessary width. The low-pressure eccentric seating will consist of a sleeve of the diameter of the couplings, keyed on an enlarged part of the shaft.

The intermediate-pressure eccentric seating will consist of two crank-shaft coupling-disks.

Each backing eccentric will be securely keyed on its seating, and each forward-motion eccentric will be secured to the corresponding backing eccentric by through-bolts in slotted holes, the holes to be filled up after the eccentrics are set.

The eccentrics will be interchangeable.

0. ECCENTRIC-STRAPS.

They will be of composition, finished all over, made with flanges to fit the recesses of eccentrics and with lugs for the clamping-bolts and for the eccentric-rods. The two parts of each strap will be held together by two steel bolts with finished heads, lock-nuts, and split-pins, and fitted with channeled brass distance pieces. Each strap will be accurately and smoothly bored to fit the eccentrics both on face and recesses, and properly channeled for oil. All straps will be interchangeable.

1. ECCENTRIC-RODS.

They will be of forged steel, finished all over. Each rod will have a T-head secured to its eccentric-strap by two steel stud-bolts with nuts locked in place. The length between centers will be 38⅝ inches.

The upper end of each rod will be forked to span the link and fitted with brasses made adjustable, which will be interchangeable for all the rods.

The two brasses in the forks of each rod must be fitted accurately in line with each other and smoothly bored to fit the link-pins.





All go-ahead rods will be interchangeable and all backing rods will be interchangeable.

2. MAIN-LINKS.

They will be of double-bar pattern, of forged steel, finished all over.

They will all have the pins for eccentric-rods forged on and finished to not less than 10 inches between centers. The pins for suspension bars will be placed as shown in the drawings, and will be forged on the links. Each pair of bars will be secured together by through-bolts, and thimbles fitted with finished steel-nuts well secured with split-pins.

All the links will be interchangeable.

3. LINK-BLOCKS.

They will be of forged steel, finished all over. The blocks will be forged with link-block pins.

They will terminate at each end in a pair of jaws to span the corresponding bar on the link. These jaws will be fitted with composition gibs, finished to the curve of the links, adjustable by two set-screws, with fine threads, at top and bottom.

4. SUSPENSION-LINKS.

Each Stephenson link will be suspended from the corresponding arm of the reversing-shaft by two flat-sided forged steel suspension-links.

The ends of these links will be fitted with composition bushings, bored to fit suspension-pins on main links and pins on reversing-shaft arms.

5. VALVE-STEM CROSS-HEADS AND GUIDES.

The intermediate-pressure valve-stems will have a cast-steel cross-head, the cross-head taking hold of the link-block directly. The boss of each arm of each cross-head will be bored to receive the valve-stem, secured as heretofore specified. The cross-head guides will be cast-steel





brackets, bolted to the valve-chest covers on the high-pressure and intermediate-pressure cylinders, and to the valve-chest on the low-pressure cylinder. The high-pressure and low-pressure valve-stems will take hold of the link-blocks directly.

6. REVERSING-GEAR.

The reversing-gear for each engine will consist of a steam cylinder and a hydraulic controlling cylinder placed vertically and acting directly on an arm fixed on the reversing-shaft. Each will be placed on the outboard side of its engine, between the intermediate-pressure and low-pressure cylinders, and secured to bed-plate. The steam piston-rod will be secured to a steel cross-head, working in suitable guides, and connecting with the arm on the reversing-shaft. The piston-rod will pass through the controlling cylinder with uniform diameter. The controlling cylinder will be of composition. The valve of the steam-cylinder will be of the piston pattern, of composition, working in a composition-lined valve-chest. There will be a by-pass valve on the hydraulic cylinder, which will be worked by a continuation of the stem of the steam piston-valve. These valves will be worked by a system of differential levers, the primary motion being derived from the hand-lever on the working-platform and the secondary motion from a pin on the reversing-arm, all parts being so adjusted that the reversing-engine shall follow the motion of the hand-lever and be firmly held when stopped. There will be a stop-cock in the by-pass pipe of the hydraulic cylinder, and a pump for reversing by hand will be connected to the hydraulic cylinder, with its lever convenient to the working-platform. The by-pass pipes will pass through the valve-box of the hand-pump in such a way as to leave the hand arrangement always in gear. The piston of the hydraulic cylinder will be packed by two cup-leathers. Steam for the reversing-engine will be taken from the auxiliary steam-pipe.





7. REVERSING-SHAFTS.

There will be one forged steel reversing-shaft for each engine. It will have five arms, two connecting with the reversing-engine and one with each link. The shaft will be supported by suitable bearings. Each reversing-arm will be made with a slot, fitted with a composition block, to which the suspension-rods will be attached. Each block will be adjustable in the slot of its arm by a screw and hand-wheel with approved locking device, and will be fitted with a suitable index. The slots in these arms will be so arranged that the links may always be thrown into full backward gear irrespective of the position of the block in the slot; and the length of the slots will be such that the cut-off may be varied from 0.5 to 0.7 of the stroke. All the arms will be neatly fitted and keyed to the shafts.

8. REVERSING-SHAFT BEARINGS.

They will be made of cast-steel, with bottom brasses and composition caps, and will be securely bolted to their supports. They will be bored to fit the journals of the shafts.

The caps will be secured by bolts fitted with lock-nuts.

9. EXHAUST-PIPES.

A 5¾-inch pipe will lead from the exhaust side of each high-pressure valve-chest, with a 5¾-inch branch to each end of the valve-chest of the corresponding intermediate cylinder. A 7¾-inch pipe will lead from the exhaust side of each intermediate valve-chest to the valve-chest of the corresponding low-pressure cylinder.

Each low-pressure cylinder will have a 9¾-inch exhaust-nozzle.

0. WORKING-PLATFORMS.

The floor between the engines will be conveniently arranged to serve as working-platforms. The counters, revolution-indicators, clock, gauges, telegraph-dials, and





other engine-room fittings will be so placed near the working-platform as to be in full view while working the engines. Speaking-tube mouth-pieces and telegraph-levers will be conveniently placed.

41. WORKING-LEVERS AND GEAR.

There will be at working-platform the following hand-gear for each engine, viz:

One reversing-lever;
Three cylinder drain-cock levers;
Hand-reversing pump-lever;
Throttle-valve hand-wheel;
Bleeder-valve hand-wheel;
Reversing-engine stop-valve hand-wheel.

All levers will have spring-latches of "locomotive pattern". The latches on reversing-levers will be of May's pattern or equivalent.

42. SHAFTS.

All the crank, thrust, and propeller-shafts will be of steel. Each length will be forged solid in one piece, and will have a hole drilled axially through it from end to end.

All shafts will be finished all over.

43. CRANK-SHAFTS.

There will be three sections of crank-shafts for each propelling-engine, interchangeable and reversible. Each section will have a crank of 10 inches throw.

Each crank-shaft will have a coupling-disk, 1½ inches thick and 12 inches diameter, forged on each end.

The length of each section of shaft will be 2 feet 7½ inches over all. There will be a journal on each side of each crank 5½ inches in diameter.

The crank-pins will be 6 inches diameter and 6 inches long. The crank-webs will each be 7½ inches wide and 4 inches thick; the webs to be chamfered, as shown in drawing. The crank-pins must be accurately parallel to the main journals. All journals are to be smoothly and





accurately turned, and when finished will be tested and their accuracy proved. There will be a hole 3 inches in diameter bored axially through each shaft and crank-pin. When bolted together the cranks will be at angles of 120°.

The forward end of the hole in crank-pin will be closed by a brass plate fastened on with countersunk screws.

One radial ½-inch hole will be drilled in each crank-pin from the outside to the bore.

The various lengths of the crank-shafts will be coupled to each other by 1⅜-inch bolts. There will be six bolts in each coupling, all holes being drilled or reamed to template, so that the couplings will match indiscriminately. The bolts will be made of forged steel, finished to fit the hole snugly, and each fitted with wrought-iron nut and split-pin.

On the after coupling-disk of the crank-shafts there will be a worm-wheel for turning the shaft.

44. THRUST-SHAFTS.

They will be 5¾ inches in diameter, with 2⅞-inch axial holes. Each shaft will have seven thrust-collars 1¼ inches thick, with spaces of 1⅝ inches, the collars to be 9 inches outside diameter. The thrust-shaft will be enlarged at the outer end, and bored to receive end of propeller-shaft, which will be secured to it by feathers, and a screw-coupling.

45. PROPELLER-SHAFTS.

The propeller-shafts will each be in two lengths. A 3-inch hole will be bored in both sections of shaft.

The forward section of each shaft will be 6 inches diameter, cased with composition ½ inch thick. The casing will be shrunk and pinned on, and must be watertight. The casings must be accurately and smoothly turned to form journals.

The after end of forward section will have a coupling-disk forged on.

The after section will be 6 inches diameter, cased with composition ½ inch thick where it passes through the





bracket-bearing, up to and beyond the tapered casing, and will enter 1 inch into the propeller-boss. It will have forged on the forward end a coupling-disk.

The after end will be tapered to fit the bore of the propeller-boss, and will be fitted for two feather-keys.

There will be a water-tight plug in the after end.

The hole in this section of the shaft will be 3 inches diameter, except in that part passing through the propeller-hub, where it will be tapered so as not to reduce the thickness of the metal around the hole.

The two lengths of each propeller-shaft will be coupled to each other by six bolts, with heads and nuts made perfectly water-tight when set up. The bolts will be fitted with nuts locked in place.

There will be at the forward end of the after section of each propeller-shaft a cast-steel casing to form a fair water-line from the end of the stern-tube to the shaft. The casing will be finished on the outside and bored to fit the shaft and couplings.

The shaft, couplings, and casings will be well coated with the same composition as the hull.

8. LUBRICATION.

All working parts of the machinery will be fitted with efficient lubricators, each with a sufficient oil capacity for four hours' running. Each main crank-pin will have a centrifugal oiling device on the after face of the crank, made of composition, and fastened to the crank by countersunk screws. Each centrifugal oiler will be fed by a pipe leading from a fixed sight-feed cup in an accessible position. Each main crank-pin will also be oiled by cups carried on the cross-head, taking oil from wicks overhead; the oil to be carried to the crank-pins by brass pipes secured to the connecting-rods. These pipes will have union joints where connected to oil cups.

There will be a small oil-tank, with glass gauge, placed in a convenient position, and connected by pipes with a closed oil-box at each crank-shaft bearing, so that, when necessary, oil can be supplied to the journals under a



head. From each of these boxes two tubes will lead to the bearing, each with valve adjustment, and with a sight-feed with a well-protected glass tube.

Each main cross-head journal will take oil from an overhead wick-cup.

Each cross-head guide will be oiled by dragglers taking oil from a cup at the bottom, and will have an oil-cup at the top.

There will be a globe oil-cup for each piston-rod and one for each end of each valve-stem; also one for each valve. These will be placed sufficiently high to insure the oil running where desired without regard to the trim of the vessel.

Each eccentric will have a long oil-cup fed by a drip-pipe, so arranged that the eccentric will be lubricated in all positions. The upper end of each eccentric-rod will carry a wiper oil-cup on each fork, these cups to take oil from wicks in cups easily adjusted to the various positions of the gear.

There will be fitted to each main steam-pipe, close to valve-chest, a Detroit or equivalent steam sight-feed oil-cup of one quart capacity, with gauge-glass. As far as possible all the oil for the moving parts of each engine, except main bearings, will be supplied from one oil-box on the cylinder, with separate valve, sight-feed, and pipe for each part to be oiled. There will be steam sight-feed cups on the circulating, each blowing, main-feed, air-pump, and bilge-pump engine. Each auxiliary engine will have a continuous automatic lubricator of approved pattern. All working parts for which oil-cups are not specified or shown in drawings will have oiling-gear of approved design, such that they can be oiled without slowing. Moving oil-cups, where necessary, will have removable covers. The supply of oil to various parts is to be easily regulated. All oil-cups and their fittings, except such as are cast on bearings, will be of finished cast-brass, or of sheet-brass or copper, as may be directed, with all seams brazed.



47. OIL-DRIPS.

All fixed bearings will have drip-cups cast on where possible, otherwise they will be of cast-brass, properly applied. All moving parts will have drip-cups or pans cast on engine-frames where directed, otherwise to be substantially made of sheet-brass or copper, with brazed seams. All drip-cups will have drain-pipes and cocks of at least ½ inch diameter, which can be used while the engines are in operation.

48. JOURNAL-BOXES.

All journals or moving parts of iron or steel will run, unless otherwise specified, in composition boxes. These boxes will be lined with approved anti-friction metal where directed. All adjustable bearings will be provided with channeled-brass chipping-pieces, securely held in place and easily removable.

49. MANDRELS FOR WHITE-METAL BEARINGS.

Hollow cast-iron mandrels will be furnished for forming the white-metal linings of crank-pin, crank-shaft, line-shaft, and thrust-bearings. All these will be smoothly and accurately turned to size, and packed so as to be perfectly protected.

50. STUFFING-BOXES.

All iron boxes will be bushed with composition. All glands will be of composition and fitted with approved means of adjustment while the engines are in operation, and those not fitted with pinion-nuts and spur-rings will have lock-nuts and split-pins. Metallic packing of approved kind, and equal in all respect to Watson's, will be fitted in stuffing-boxes of all piston-rods and valve-stems of main and auxiliary engines over 1¾ inches diameter. Stuffing-boxes of piston-rods and valve-stems between ¾ and 1¾ inches diameter will be fitted with metallic packing of Katzenstein's pattern, or equivalent.





51. BOLTS AND NUTS.

All bolt-heads and nuts less than 2 inches, except in special cases, will conform to the United States Navy standard. Screw-threads on bolts and nuts must in all cases conform to the above standard. All finished bolts, except as directed, will be kept from turning by dowels or other suitable devices.

The nuts of all bolts on moving parts and on pillow-blocks, and elsewhere as shown, will be fitted with keepers, and the bolts will extend beyond the nuts, without threads, and fitted with split-pins.

52. THRUST-BEARINGS.

The bearing will be in two parts, of cast-iron, with white-metal linings. The lower part will be planed to fit the bed-plate. The cap will be faced to fit longitudinal recesses in the upper flanges of bearing, and will be held down by wrought-iron bolts. Each cap will have a box cast on top, with a hinged cover. There will also be projecting lugs on cap and bearing fitting snugly and taking the end-thrust of the cap.

The core of the bearing will form an oil-trough, from which there will lead an oil-hole to each collar and each recess, the white-metal being properly channeled for distribution of oil. Both forward and abaft the thrust-collars will be a composition bearing for taking the weight of the shaft. The cap for this bearing will be of cast-iron lined with white-metal. These bearings will be adjustable vertically by wedges with regulating-screws.

At each end of each thrust-bearing there will be a divided stuffing-box and gland to prevent escape of oil. At the bottom of each thrust-bearing there will be a fore-and-aft channel connecting all the bearing recesses; a drain-cock to be fitted at each end.

The oil-trough will also be fitted with a cooling coil. The adjusting, both fore-and-aft and athwartship, will be done by means of wedges bearing against lips on the bed-plate. The caps will be fitted with eye-bolts for convenience of handling.



53. JACKS FOR COUPLING-BOLTS.

A hydraulic jack of approved pattern will be fitted for withdrawing the bolts of the shaft-couplings.

54. STERN-TUBE STUFFING-BOXES.

At the forward end of each stern-tube there will be a composition stuffing-box, made in halves, divided longitudinally. It will be bolted to the flange on the forward end of the stern-tube bushing. The two parts will be bolted together along the longitudinal division by proper flanges. The follower will be of composition, in two parts, with a space of 1¼ inches between the parts on each side. The packing spaces will be about 6 inches deep and 1 inch wide.

The follower-bolts will be of naval brass. To each stuffing-box, abaft the packing, a 1-inch pipe will be attached, leading to the engine-room bilge. It will also be connected with the engine-room water-service pipes, and will be provided with valves, so that the bearing can be drained into the bilge or washed out by water from the engine-room pump at will.

55. STERN-TUBE BEARINGS.

The forward section of propeller-shaft will be supported in the stern-tube on three bearings, one at each end of the tube and one at the middle, lined with lignum-vitæ strips, bored in place to perfect alignment.

In the stern-tube will be riveted six cast-steel rings of U-section, arranged to properly support the composition lignum-vitæ-lined bearings.

The middle and outer bearings will be contained in the same tube, secured in place by a flange bolted to the outer steel ring.

The lignum-vitæ will be placed in strips in the bearings, so arranged that the bearing surface will be on the end of the wood, and held in dove-tailed grooves by suitable collars at each end. The lignum-vitæ to be bored, after being well water-soaked, to a loose fit on the shaft.





The inner lignum-vitæ bearing to be arranged so as to be withdrawn by removing the inner stuffing-box. The middle and outer bearing-tube to be withdrawn outboard.

These tubes to be divided longitudinally in halves.

56. STERN-BRACKET BEARINGS.

Each stern-bracket bearing will have a neatly-fitting composition lining, made in halves, divided longitudinally. The internal diameter of the boss will be such that, when the bushing is removed, the after section of propeller-shaft can be sufficiently inclined to have its forward coupling clear the coupling of the next section of shaft. It will have a lignum-vitæ bearing, fitted as in the stern-tube. The lignum-vitæ will be held in place at the after end by a flat ring bolted to the lining. A cast-steel sleeve, ½ inch thick, will be secured to each stern-bracket by four ¾-inch screws, to form a fair water-line to the propeller-boss. At the forward end of each bearing there will be a composition sleeve, ½ inch thick, secured to and supported by an extension of the lining before mentioned. This sleeve will be shaped to form a fair water-line from the shaft to the stern-bracket boss, and will be finished on the outside.

57. SCREW-PROPELLERS.

They will be of manganese-bronze or approved equivalent metal. The starboard propeller will be right and the port one left-handed. Each blade will be firmly bolted to the boss by tap-bolts of naval brass, secured by lock-plates. The recesses for the bolt-heads will be covered by composition plates held by countersunk screws, and finished to form a smooth surface fair with the boss. The holes in the flanges of blades will be oblong, so as to allow adjustment of pitch.

Each boss will be accurately bored to fit the taper on after end of shaft and fitted with two feather-keys. Each propeller will be held on the shaft by a nut screwed on and locked in place. The shaft-casing will enter about 1



inch into the propeller-boss and be fitted water-tight. Each boss will be finished at the after end by a composition cap bolted on water-tight. The bosses and caps will be finished all over. The blades will be cast as smoothly as possible and have any roughness removed. The flanges of the blades will be turned and faced to fit the recesses in the bosses accurately, and, after being secured in place, must have the edges made fair.

58. CONDENSER.

The main condenser will be cylindrical, 4 feet internal diameter, cast of composition, not over $\frac{7}{16}$ inch thick.

There will be the following openings in the condenser, each with properly faced flanges, viz:

Two for main exhaust-pipes, $9\frac{3}{4}$ inches diameter;

One 6 inches diameter for air and circulating-pump exhaust-pipe, the auxiliary machinery, and the bleeder;

One for air-pump suction-pipe, 7 inches diameter;

One 6-inch hand-hole, with nozzle for salt-feed spray and soda-cock in the cover;

One 7-inch hand-hole in the air-pump suction-nozzle, to be used for cleaning out condenser. The cover on this hand-hole will have a nozzle for boiling-out pipe.

The main condenser will have the flange at each end extended to secure it to the supporting-brackets. There will also be brackets on the side of condenser, which will by means of additional brackets be secured to the air-pump frames.

The condenser tube-sheets will be made of composition, $\frac{7}{8}$ inch thick, with smoothly finished holes for the tubes, tapped and fitted with screw-glands for packing the tubes. There will be a hand-hole at the lower part of each tube-sheet. The glands will be beaded at outer ends to prevent tubes from crawling, and will be slotted to admit a tool for screwing up. Cotton-tape packing will be used. There will be 1,772 seamless-drawn brass tubes, $\frac{5}{8}$ inch outside diameter, No. 20 B. W. G. in thickness. The tubes will be 6 feet $13\frac{1}{2}$ inches long between tube-sheets, and will be spaced $1\frac{5}{16}$ inch between centers. The cooling surface will be about 1,820 square feet, measured on the outside of the tubes.



The condenser-shell will have flanges to connect with the tube-sheets. The tube-sheets will be secured to the flanges of the shell by naval-brass collar-bolts, which will also be used for fastening the circulating-water chests.

The chest for entrance and exit of circulating water will be made of composition, with a division-plate in the middle and with a man-hole. The inlet and outlet-nozzles will each be 6 inches in diameter of opening.

The water-chest at the other end of the condenser will be cast as shown. It will have a man-hole. There will be two stay-bolts to connect the water-chest to the tube-sheet.

There will be two braces of rolled naval brass connecting the tube-sheets, each ¾ inch in diameter, and each passing through a stay-tube 1½ inches external diameter and ¼ inch thick.

Baffle-plates of brass will be fitted, as shown, to direct the steam over all the tubes. Plates will be provided for supporting the tubes and to act also as baffle-plates. In front of the main exhaust-nozzle, above the tubes, will be a deflecting-plate, supported as shown.

A copper tank, pipe, and a cock will be provided for admitting an alkaline solution into the condenser—this pipe to connect with the salt-feed spray; the tank to be of at least 5 gallons capacity and conveniently placed. A 1-inch branch from the auxiliary steam-pipe will lead to the bottom of the condenser for cleaning the tubes by boiling. Drain-cocks will be provided with pipes leading to the bilge.

All parts of the condenser, except as otherwise specified, will be made of composition. All bolts to be of naval brass. All bolts for securing flanges of pipes and man-hole plates will be standing bolts, and will, wherever possible, be screwed into the condenser-plates, with heads inside. The condenser must be perfectly tight all over and be so proved after being secured in place.

There will also be an auxiliary condenser of approved design, of a sufficient capacity for all the auxiliary machinery.



59. AIR-PUMP.

There will be a single-acting vertical air-pump, driven by a two-cylinder vertical inverted compound engine. Each steam-cylinder will be carried by two cast-steel frames supported upon brackets on the air-pump cylinders. Each of these frames will have bolting-flanges at top and bottom, and will serve as guides for the cross-head. The inside frame of each engine will form one of the crank-shaft bearings. All the frames will have faces for bolting to the condenser.

There will be one engine-cylinder over each pump-cylinder. Each pump piston-rod takes hold of the cross-head as shown.

At the middle of the crank-shaft will be a cast-iron balance-wheel, made in halves and bolted together.

The crank-shaft will have two bearings, and will have an overhanging crank for each engine, each connecting-rod taking hold of the cross-head inside of the piston-rod.

The cranks will be at an angle of 135 degrees to each other. All parts of the pumps, except where otherwise specified, will be made of composition.

Each air-pump will have a piston working in a cylinder of 12 inches bore. The pump-cylinders will be cast separate, and each will be bolted to a casing containing its foot-valves. The delivery-valve chambers are cast in one with the pump-cylinders. The stroke will be 12 inches. The pump-pistons will be cast flanged, the flange being grooved for water-packing, as shown. The pump piston-rods will be made of rolled phosphor-bronze or approved equivalent metal. There will be nine foot-valves, six valves in each piston, and six delivery-valves for each pump, all 3 inches in diameter, made of approved metal.

Each valve will be held in place by a guard and a spiral spring of phosphor-bronze or approved equivalent metal. The valves and guards must be easily removable and held firmly in place. The foot-valve seats will be in inclined positions at the bottom of the pumps, and



the delivery-valves horizontal at the highest parts of the pump-chambers. There must be no pockets in the pump-chambers underneath the delivery-valves where vapor can lodge. The gratings of the valve-seats must be so arranged that the clear opening of each valve shall be at least 5.12 square inches. The bonnets will be well ribbed, as shown, and provided with jack-bolts and eye-bolts. There will be one suction-nozzle, 5½ inches in diameter. A 7-inch copper pipe will lead from the bottom of the condenser and be breeched, there being a 5½-inch branch for each pump-cylinder. Each of these branches will have a straightway-valve.

The engine-cylinders will be 5¾ and 11 inches bore, respectively. The cylinders, with their valve-chests, valve-chest covers, and slide-valves, will be made of cast-iron. The high-pressure and low-pressure valve-chests of each engine will be connected by a copper pipe 2 inches in diameter.

The steam-pistons and all cylinder-covers will be made of cast-iron. The pump-cylinder covers will be made in halves and bolted together, as shown.

The crank-shafts, steam piston-rods, valve-rods, cross-heads, and connecting-rods will be made of forged steel, the piston-rod and cross-head being in one piece. The pistons will be fitted with cast-iron packing-rings.

The crank-shafts will be 2½ inches diameter, tapering from the center, as shown, with bearings 5 inches long. Each crank-pin will be 3 inches diameter and 2 inches long; next to the web, and at the end of the pin it is reduced to a diameter of 2½ inches, as shown. Each cylinder will have a slide-valve, worked through gear, as shown.

The engine will take steam from a branch of the main steam-pipe, with a stop-valve having a hand-wheel at the working-platform, and will exhaust by a special pipe into the condenser, and there will also be a pipe through which it can exhaust into the low-pressure receiver.

The air-pump, together with its condenser, must maintain a vacuum of within 4 inches of mercury of the



atmospheric barometer with the propelling-engines at full power under forced draught.

60. CIRCULATING-PUMP.

There will be a double-inlet centrifugal circulating-pump for the main condenser, driven by an inclosed multi-cylinder engine. The pump must be capable of discharging 2,600 gallons of water per minute from the bilge. The pump will be made of composition, except as otherwise specified. The pump-casing will be made in two parts, divided in a horizontal plane, the upper part with conveniences for handling. The suction-nozzle will have an opening for sea-suction of not less than 6 inches diameter, and a 6-inch opening for bilge-suction. The pump-runners will be smoothly cored, finished on the outside, and perfectly balanced. The shafts will be of phosphor-bronze or approved equivalent metal. The bearings will consist of sections of lignum-vitæ on end of grain, dovetailed into composition split-sleeves, which will be well secured against turning. The stuffing-box glands will be each in two parts. There will be an air-cock at the top of the pump-casing and a drain-cock at the bottom. The pump-casings must be made as light as possible consistent with strength, and must be smoothly cored, with easy bends wherever the direction of the flow of water is changed.

61. CIRCULATING-PUMP ENGINE.

It will be of the inclosed multi-cylinder type, of approved pattern, of sufficient power to secure the results above specified. The engine-valves must be of either the slide or piston type.

62. CIRCULATING-PUMP CONNECTIONS.

The circulating-pump will be fitted with pipes and valves to draw from the sea or engine-room bilge, and will deliver into the condenser; or direct to the outboard-delivery pipe by a pipe connecting inlet and outlet of



condenser. There will be a straightway valve in the inlet-pipe, the outlet-pipe, and the pipe connecting the inlet and outlet pipes.

The injection and delivery pipes for condenser circulation will be not less than 6 inches internal diameter.

There will be stop-valves in the pipes leading from the sea and from the bilge to the circulating-pump. These valves will be so connected by a locking device that when one is open the other is shut.

63. SEA-INJECTION VALVE.

There will be a straightway screw main injection-valve of not less than 6 inches diameter in the engine compartment.

There will be a strainer at the ship's side. The hand-wheel of this valve must be easily accessible above the engine-room floor-plates.

There will be a 1-inch steam-pipe leading from the auxiliary steam-pipe to the injection-pipe outside of injection-valve. This pipe to have a valve at each end.

64. BILGE-INJECTION VALVE.

It will be as specified under the head of "Bilge-suction pipes."

65. OUTBOARD-DELIVERY VALVE.

There will be in the engine compartment a main outboard-delivery valve of the same size and type as main injection-valve. The hand-wheel will be accessible from the engine-room.

66. FEED-TANK.

There will be a feed-tank placed as shown in the drawing. It will have a capacity of about 270 gallons. It will be made of $\frac{3}{16}$-inch wrought-iron. It will be stayed internally as may be directed. The tank will have at least 40 cubic inches of rolled-zinc plates, about $\frac{1}{2}$ inch thick, suspended from the braces. The straps suspending the zinc



plates and the braces where the straps come in contact will be filed bright before fitting. The parts to be then well painted on the outside, or the joints to be made water-tight in other approved manner. A portion of the tank will be fitted as a filter, into which the water from the air-pump will be delivered. The filter will be provided with approved filtering material, and so arranged that the water will rise through it, and that the filtering material will be readily accessible. The tank will have a man-hole with bolted cover, and will have a glass water-gauge with suitable guards, shut-off cocks, and drain-cocks.

The tank and filter will have the following pipe connections: A discharge-pipe from the air-pump; an overflow-pipe leading to bilge, but so arranged that any water passing down it may be seen; a suction-pipe to feed-pumps, with valve; drain-pipes from traps, as elsewhere specified; a vapor-pipe, 2 inches diameter, of copper, No. 16 B. W. G. The vapor-pipe will lead up the engine-room hatch and discharge above the level of the awnings, where it will have a suitable hood, or it may be led into the main escape-pipe. The feed-pump suction will be provided with a balanced valve operated by a copper float in the feed-tank, so arranged that it will allow no air to enter the feed-pipe. All trap-discharges and drains will enter the feed-tank well below the ordinary water-level.

67. FEED-TANK SUCTION-PIPES.

A suction-pipe will lead to the main and auxiliary feed-pumps. The auxiliary feed-pump will have its suction join the main feed-suction. A non-return valve will be fitted in this pipe close to auxiliary feed-pump.

68. SUCTION-PIPE FROM BOTTOM OF CONDENSER.

From each air-pump channel-way below the foot-valves a 1¾-inch pipe will lead to the main feed-pump suction-pipe, with a screw-down non-return valve.





69. SEA-SUCTION PIPES.

A pipe will lead from the sea-suction valve in the engine-room to the fire and bilge-pump, the auxiliary-pump, the auxiliary feed-pump, and the circulating-pump for auxiliary condenser. A pipe will also lead from a special sea-valve, fitted where directed, to the distiller circulating-pump. Each of these pipes will be of the same bore as the nozzle on the pump with which it connects. Each sea-suction will be controlled by a valve which will not permit sea-water to enter any of the bilge-suction pipes or the feed-tank suction-pipe.

70. BILGE-SUCTION PIPES.

There will be the following suction-pipes from the bilge to the various pumps:

A 6-inch copper pipe will connect to the circulating-pump, with a valve close to the pump, as before specified. This pipe will connect directly with the bilge, with a non-return valve which can be lifted from its seat by means of a sliding-stem, but without means of fastening it shut except by lashing the lever by which its stem is worked.

The bilge-suction pipe will have a strainer.

There will be provided in the engine-room a manifold or suction-box, with the following connections, viz:

A pipe of size of suction of fire and bilge-pump leading from the lowest part of the compartment abaft the engine-room;

A pipe of size of suction of fire and bilge-pump from the engine-room bilge;

A pipe to the fire and bilge-pump of the size of fire and bilge-pump suction.

All these pipes will be provided with screw-down non-return valves. A Macomb bilge-strainer will be inserted in the pipes between the box and pump.

There will be no strainers or valves in any of these pipes other than those herein specified.

The auxiliary feed-pump will have a suction-pipe of the full size of its suction-nozzle, connecting with the



bilge, as may be directed. The auxiliary feed-pump will also have suction-pipes leading to the main air-ducts. The suctions to each pump will lead to a valve-box and strainer fitted as before specified for the suctions to the fire and bilge-pumps.

The lower ends of all bilge-suction pipes will be of galvanized iron. Care will be taken that all the copper bilge-pipes are led sufficiently high to keep them out of the bilge-water under ordinary circumstances.

71. FIRE AND BILGE-PUMP.

There will be in the engine-room a pump of approved design, which will be used as a fire and bilge-pump. It will have a capacity of 250 gallons per minute, with steam cylinder of suitable size to work as a fire-pump with steam of 60 lbs. pressure. This pump will have suctions from the sea and the bilge as may be directed, and will deliver into the fire-main and overboard.

72. ENGINE-ROOM AUXILIARY PUMPS.

There will be in each engine-room an auxiliary pump of approved pattern, of 100 gallons capacity per minute, and with cylinders of proper proportion, to be used as a fire-pump with steam of 60 lbs. pressure. This pump will have suction from the sea only, and will deliver into the engine-room water-service pipes and fire-main only.

73. ENGINE-ROOM WATER SERVICE.

There will be in the engine-room a 2-inch pipe connected with a sea-valve and with a special delivery from the auxiliary pump, with branches leading to the different parts of each engine, as follows:

A ¾-inch branch connected by a union-joint with a pipe screwed into the cap of each crank-shaft bearing, and leading through brasses to top of journal;

A ¾-inch branch to the bottom brass of each crank-shaft bearing;

Two ¾-inch pipes to each crank-pin;

Two ½-inch pipes to each cross-head;



One ¾-inch pipe to each go-ahead cross-head guide;
One ¾-inch pipe to each pair of eccentrics;
One 1-inch pipe to each thrust-bearing;
One ¾-inch pipe to each line-shaft bearing;
Two ¾-inch pipes to air-pump engine and to the circulating-pump engine.

All of the above to have detachable sprays or short lengths of hose, as directed, and where directed to have pivoted nozzles.

Each branch will have a separate valve.

All the water-service pipes and fittings above the floors will be of polished brass.

74. TURNING-ENGINE AND GEAR.

There will be in the engine-room a double engine of suitable size for turning the main engines with steam of 60 lbs. pressure. This engine will drive by worm-gearing a second worm, which may be made at will to mesh with a worm-wheel on either propelling-shaft. The worm-wheel of each engine will be fitted on the after crank-shaft disk.

The turning-engine shaft will be fitted with a ratchet-wrench, of approved design, for turning by hand.

The turning-engine will have piston-valves, and will be made reversible by means of a change-valve moved by a screw and hand-wheel.

The turning wheels will be of cast-steel with cut teeth.

75. SECURING ENGINES IN VESSEL.

The engines will be adjusted and aligned upon the engine-keelsons, and when accurately in line snugly-fitting wrought-iron washers will be fitted around all holding-down bolts. The holding-down bolts will be firmly set up and bolts and nuts locked in place.

When finally secured all shafting must be accurately in line, with the vessel at load-draught and ordinary stowage.

All parts of the machinery and boilers will be secured in an approved manner, to prevent displacement when the vessel is used for ramming.





76. STEAM AND VACUUM-GAUGES.

There will be the following gauges, in polished brass cases, suitably engraved to show to what they are connected; all to be of approved pattern and equal to "Lane's improved," with seamless tubes:

One on each boiler;

One connected to each main steam-pipe;

One connected to each intermediate valve-chest;

One connected to each low-pressure valve-chest;

One connected to each condenser.

All the above will have 8½-inch dials; those in engine-room to be at the working-platform.

Also the following with 4½-inch dials:

One on auxiliary steam-pipe in engine-room and fire-room;

One on each circuit of radiator-pipes, near the reducing-valve.

The gauges on valve-chests will be plainly marked with the limit of pressure permissible. The gauges on intermediate and low-pressure valve-chests will indicate both pressure and vacuum.

A mercurial vacuum-gauge will be connected to each condenser.

77. THERMOMETERS.

There will be the following thermometers—all to be permanent fixtures, with their stems and bulbs protected by brass covers; the casings and fittings to be of polished brass:

One on hot-well;

One on feed-tank;

One on main feed-pipe in fire-room;

One on main injection-pipe;

One on main outboard-delivery pipe;

One on each main steam-pipe close to engine.

The hot-well and feed thermometers will be so fitted as to waste no feed-water.

There will also be furnished:

Two spare water-thermometers complete;

Six spare steam-thermometers complete;





Two standardized thermometers, graduated on stem and reading to $\frac{1}{10}$ degree Fahrenheit; stems to be at least 20 inches long; each thermometer to be in a rubber-lined brass case, and each case to be suspended by springs in a suitable permanent locked case in engine-room. These thermometers must be equal to those made by H. J. Green, and be accompanied by certificates of standardization.

78. REVOLUTION-INDICATORS.

They will be of such approved pattern as shall not be affected to a perceptible degree by the motion of the ship or by changes of temperature. They must be worked off the engines by positive motions, and must be so fitted that changes of engine speed shall not produce violent fluctuations of the indices. There will be two in the engine-room, one to show the speed of each propeller.

79. REVOLUTION-COUNTERS.

They will be of the continuous rotary type, to register from 1 to 1,000,000, each worked by positive motion; each to be in a polished brass case. There will be fitted:

One for each main engine;

One for main air-pump;

One for main circulating-pump.

Tell-tales will be fitted on the bridge and in the conning-tower, to show the direction of revolution of the main engines.

80. ENGINE-ROOM TELEGRAPHS.

A repeating-telegraph of approved pattern will be fitted for each engine with its dial at the working-platform, and connected to transmitters in conning-tower, in wheel-house, and on bridge. The connections are to be made in such manner that the chance of derangement shall be minimized.

81. SPEAKING-TUBES.

They will be made of copper not less than No. 20 B. W. G. They will connect the engine-room with the fire-room; the engine-room to the pilot-house, conning-tower,



bridge, and to the chief engineer's room; the fire-room with the upper deck close to the top of the ash-hoist, and elsewhere as required. Each tube will be fitted at each end with a mouth-piece and approved annunciator; the mouth-pieces to be connected to short flexible pipes where required. All mouth-pieces or pipes will be plainly marked. The tubes will be suitably cased where necessary.

82. ENGINE-INDICATORS.

An indicator connection will be made to each end of each cylinder of main engines, and to each end of each steam and water-cylinder of air-pump, as near as possible to the bore of the cylinder, and so as to be easily accessible. Each indicator on cylinders of main engines, when in place, will be connected to but one end of a cylinder. The connecting pipes will be 1-inch bore, without bends The indicator-motion of each engine and air-pump will be so fitted that both indicators on its cylinder can be connected at the same time. The motions of the indicator-barrels must be accurately coincident with the motion of the corresponding pistons, and such as to give a motion of not less than 4 inches. The steam-cylinders of all auxiliary engines will have holes tapped for indicator-fittings, and then plugged. These engines will have portable indicator-motions fitted, then removed and suitably marked and stowed. Where auxiliary engines are duplicated but one set of indicator-motion fittings need be supplied for all of each kind.

Six indicators will be furnished for the engine-room. Each indicator will have two springs of approved scales.

The indicators will be of approved type, with detent-motion and with adjustable tension to the barrel-spring. They will be nickel-plated, and will be complete with all attachments. One extra cock-attachment will be furnished with each indicator. Each indicator will be in a separate locked case; each case to be suitably marked on a brass plate, and each case to be conveniently stowed.





83. ENGINE-ROOM DESK.

A black-walnut desk of approved pattern, with locked drawers, and with a locked cabinet of pigeon-holes, will be fitted in the engine-room where directed.

84. CLOCKS.

There will be in the engine-room, close to the counters, an eight-day clock of approved pattern, with second-hand, in a polished brass case, with 8½-inch dial.

There will be in the fire-room a similar clock, with an outer dust-tight case with heavy plate-glass.

85. VENTILATING-FANS.

An exhausting fan with a capacity of at least 2,000 cubic feet of air per minute will be fitted in the engine-room. Air-ducts will be led to this fan with adjustable openings so arranged as to thoroughly ventilate the engine-rooms and shaft-alleys; the air to be discharged through ducts arranged as may be directed.

Each fan will be driven by an independent engine of the same kind as specified for the fire-room blowers.

86. BOILERS.

There will be two straightway fire-tubular boilers. The outside diameter will be about 8 feet 9½ inches, and the length about 17 feet.

The total grate-surface will be about 78 square feet, and the total heating-surface about 2,640 square feet.

The boilers will be placed as shown.

87. BOILER MATERIAL.

All plates used in the construction of the boilers will be open-hearth steel. The rivets will be of open-hearth or Clapp-Griffith's steel. All material will be tested as elsewhere specified.





88. BOILER-SHELLS.

They will be made of ¾-inch plates, the shell of each boiler to be made in two rings; each ring of two plates.

89. BOILER-HEADS.

Each head of each boiler will be made of two plates. The upper plate of each head will be ¾ inch thick, curved to a radius of 2 feet 6¾ inches at the front and 2 feet 6 inches at the back. The lower plate of each head will be ¾ inch thick. The heads will be flanged inwardly at circumference and outwardly at the furnaces. The heads at the back end will be stiffened by vertical T-bars, as shown in drawings.

90. BOILER-TUBE SHEETS.

They will be ¾ inch thick. Each pair of tube-sheets must be accurately parallel. All tube-holes will be slightly rounded at the edges. The holes for stay-tubes will be tapped in place.

91. BOILER-TUBES.

They will be of steel, lap-welded and drawn, equal to the best in the market, and subject to the approval of the Bureau of Steam Engineering. There will be 56 stay-tubes and 258 ordinary tubes in each boiler, 6 feet 10½ inches long between tube-sheets. All tubes will be two inches external diameter, except where otherwise specified. The ordinary tubes will be No. 14 B. W. G. in thickness, and will be swelled to $2\frac{1}{16}$ inches external diameter at the back ends. The front ends will be expanded in the tube-sheets, beaded over into a counterbore in the tube-sheets, and will be protected from the action of the flame by rings driven in place. Any other manner of securing and protecting tubes must be approved by the Bureau of Steam Engineering. No method must be used which will reduce the calorimeter. The method of protection must be such as will not interfere with the use of ferrules, and will not cause injury to the tube-sheet when tubes are cut out.





The stay-tubes will be No. 7 B. W. G. in thickness. They will be reinforced at both ends to an external diameter of 2⅛ inches, leaving the bore of the tube uniform from end to end. They will then be swelled at the back end to 2¼ inches external diameter. They will be threaded parallel at combustion-chamber ends, and taper at back ends to fit threads in tube-sheets. They will be screwed into the tube-sheets to a tight joint at the back end, and will be made tight at the front ends by expanding and beading. All expanding will be done by approved tools. Cast-iron ferrules of 1⅜ inches internal diameter will be used to protect the ends of stay-tubes in combustion-chambers. All tubes will be spaced 3 inches from center to center vertically and 3¼ inches horizontally.

There will be in each boiler, placed as shown, a number of tubes 3 inches external diameter, and No. 4 B. W. G., which are used as braces. They will be secured in sheets similarly to the 2¼-inch stay-tubes, except that the 3-inch tubes between the front of the boiler and the front sheet of the combustion-chamber will, in addition, be fitted with nuts in the combustion-chamber.

At the front end these tubes will have a plug with a pipe attachment.

92. COMBUSTION-CHAMBERS.

There will be two combustion-chambers in each boiler, one for each furnace. They will be made of ½-inch plates, except the tube-sheets, which will be as before specified, and the front sheet of the chamber, which will be $\frac{17}{32}$ inch thick, and will be welded to the furnace-flue. The combustion-chambers at the top will be flat and braced by girders and bolts, as shown in the drawing. The plates will be flanged where necessary, and all parts joined by single-riveting. The holes for screw stay-bolts in plates of combustion-chambers and shells will be drilled and tapped together, in place.

93. BOILER-BRACING.

The bracing of each boiler will be of steel, and placed as shown in drawings.



head, will have a stiffening-ring riveted on the outside of the boiler. The man-hole plates will be of cast-steel in dished form. Each plate will be secured by two wrought-iron dogs and two 1¼-inch studs with square nuts. Each plate will have a convenient handle.

Each of the man-holes in the top plate of heads will have a raised cast-steel ring riveted to the inside of boiler.

The hand-hole plates will be cast-steel, and will be secured by dogs and bolts.

All plates, dogs, and nuts will be indelibly marked to show to what holes they belong.

96. FURNACES.

Each furnace will be in one piece and corrugated. The thickness and diameter will be as shown in drawings. They must be perfectly circular in cross-section at all points. They will be riveted to flanges of front heads and will be welded to combustion-chamber plates so that furnace-flue and combustion-chamber plate form one piece, as shown. The corrugations of furnaces to alternate.

97. GRATE-BARS AND BEARERS.

The grate-bars will be of wrought-iron, of approved revolving or shaking pattern. They will be so fitted that they can be readily worked under forced draft without opening the furnace or ash-pit doors, and without allowing an escape of air or gases. They will also be so fitted as to be readily removed and replaced without hauling fires. The bars at sides of furnaces will be made of cast-iron to fit the corrugations.

The bearers will be made of wrought-iron, supported by wrought-iron lugs bolted to the furnace-flues.

98. BRIDGE-WALLS.

They will be made of cast-iron, so fitted as to be readily removable. They will be finished with fire-brick or other approved refractory material.



99. HANGING BRIDGES.

There will be in each combustion-chamber a hanging-bridge, as shown in outline in drawings. They are to be substantially constructed, and will be of such material and pattern as may be approved.

100. FURNACE-FRONTS.

They will be made with double walls of wrought-iron, bolted to a light frame. The space between the two walls will be in communication with the ash-pits. The upper part of the inner plate of furnace-front will be perforated as directed. The dead-plates will be made of cast-iron, and fitted so as to be easily removable. The door-openings will be as large as practicable. There will be a beading on the inside of the door-frame in wake of the inner plate of door to make the clearance as small as possible.

101. FURNACE-DOORS.

The furnace-doors will be provided with approved means for preventing the escape of gases around them when forced draft is used, and they must be protected in an approved manner from the heat of the fire. There will be three hinges to each door, all of wrought-iron. The upper hinge will be so made as to support the weight of the free end of the door, and so fitted that the sag can be easily taken up. The latches will be of wrought-iron. Drawings showing the arrangement of furnace-fronts and furnace-doors must be submitted to the Bureau of Steam Engineering before work is commenced on them.

102. AIR-DUCTS.

From each of the fire-room blowing-fans a wrought-iron trunk will lead vertically down to the space underneath the fire-room floor-plates, where the air-ducts will be located. The wrought-iron sides of ducts will be not less than $\frac{3}{16}$ inch thick. Plates will be removable where necessary to get at boilers for repairs. From the



main air-duct branches will lead to all ash-pits, each fitted with a door in front of ash-pit, and each fitted with a damper. These dampers will be so fitted as to be easily removable for repairs, and will each be provided with a lever and catch for opening and closing; to be so fitted that the amount of opening can be quickly and easily graduated, and that the dampers will close automatically when the fire-doors are opened.

The dampers must be made to work easily, and when closed must be practically air-tight. The air-ducts will be so arranged that the lower man-holes will be easily accessible. If necessary to make parts of the ducts removable for this purpose, the removable sections will be fitted with handles and with beckets for hanging them on hooks provided for the purpose.

The air-ducts below the floors must be water-tight, and so proved. All air-ducts will be tested for air-tightness under the pressure needed to produce the requisite combustion.

Man-holes will be arranged in main air-ducts where directed, with suitable covers. The covers of man-holes in fire-room floor-plates will be sufficiently heavy to be kept down by their own weight, and will rest upon suitable packing. A suction will lead from the lowest part of each main air-duct to the auxiliary feed-pump.

103. ASH-PIT DOORS.

They will be made of ⅛-inch wrought-iron, stiffened with angle or channel-iron. They will be fitted with asbestos or other approved material to make an air-tight joint where fastened to air-ducts; this packing material to be so fitted as to be protected from injury, and so as to be readily renewed. Each door will be fastened in place by wrought-iron buttons bolted to lugs on the walls of the air-duct, each button setting up on a wedge riveted to the door. Each door will have two wrought-iron handles, two wrought-iron beckets to fit hooks on boiler-front, and an eye for slinging by.



104. LAZY-BARS.

A lazy-bar with the necessary lugs will be fitted in the front of each ash-pit. Also portable lazy-bars for the furnaces.

105. ASH-PANS.

Ash-pans of ¼-inch wrought-iron, reaching from the front of furnace-flue to bridge-wall, will be fitted to all furnaces.

106. CIRCULATING-PLATES.

Each boiler will have circulating-plates fitted at each side of each nest of tubes. They will be of steel, ⅛ inch thick, in sections, so as to be easily entered into and taken out of the boilers, and will be secured in an approved manner. Each section will have two clips at upper and one at lower end for supporting it from the stay-tubes. The plates will be well painted all over with two coats of approved paint or cement.

107. UPTAKES.

They will be made of wrought-iron, No. 8 B. W. G., built on channel-iron and stiffened with angle-irons, and will be bolted to boiler-heads and shells. They will be bolted to the lower plates of smoke-pipe, with slotted holes to allow for expansion.

Outside of the uptakes will be a jacket inclosing a 3-inch air-space; this jacket will be made of No. 12 B. W. G. iron, and will extend from the tops of uptake-doors to the tops of the uptakes.

The space between the plates of the uptake will be filled with an approved incombustible non-conducting material.

108. UPTAKE-DOORS.

The uptake-doors will be made of double shells of iron of the same thickness as uptakes. The space between the shells will be filled with the same non-conducting material as in uptakes.





The hinges and latches will be made of cast-steel or wrought-iron.

Each door will also have an eye near its top for handling.

109. SMOKE-PIPE.

There will be a smoke-pipe, about 40 feet in height above the grates of the furnaces. The area of the smoke-pipe will be about 16 square feet. The lower part of the pipe will be shaped to connect with the uptakes, and will be built of No. 7 B. W. G. iron or steel. The upper part will be built of No. 9 B. W. G. iron or steel. The pipes will be well stiffened by angles.

The pipe will be finished at the top by an angle-iron to which the stay-shackles will be secured, and by a hood covering the casing, to which will be secured shackles for slinging painters. The pipe will be strongly stayed by guys and turn-buckles of approved dimensions and pattern. All joints will be butted and strapped. The pipe will be supported in an approved manner, so that its weight will not come on the uptakes.

From its junction with the uptakes to about 6 inches below the hood at top the smoke-pipe will be surrounded by a casing, leaving an annular space of 3 inches. The casing will be made of iron, No. 12 B. W. G., and strengthened by angle-irons. It will be butted and strapped, flush-riveted on the outside and open top and bottom. It will be stayed to the pipe and will be finished with a half-round iron at top. There will be doors through this casing and through smoke-pipe.

Above the smoke-pipe hatch an iron casing, No. 12 B. W. G., leaving an annular space of about 6 inches, will extend for about 5 feet, and will be finished by half-round iron. About 1 foot above this there will be a hood carried by the smoke-pipe casing.

There will be a ladder on the outside of the pipe, on the forward side, reaching to the top; this ladder to be made of round iron, bent and riveted to the pipe.



D. SMOKE-PIPE COVER.

The smoke-pipe will have a permanently-fixed cover made of wrought-iron, No. 11 B. W. G., built on angles in a slightly dished form and supported by angles riveted to the smoke-pipe. The cover will be placed above the top of the smoke-pipe so that it will not interfere with the exit of the gases, and will overlap the smoke-pipe about 18 inches all around.

L. BOILER-SADDLES.

Each boiler will rest in three saddles. Angle-irons will be riveted to the boilers to fit the saddles. They will be bolted to the saddles with allowance for expansion.

E. BOILER ATTACHMENTS.

Each boiler will have the following attachments, viz:
One steam stop-valve;
One dry-pipe;
One main feed check-valve with internal pipe;
One auxiliary feed check-valve with internal pipe;
One bottom-blow valve with internal pipe;
One surface-blow with internal pipe and scum-pan;
Two safety-valves with internal pipe;
One steam-gauge;
Two glass water-gauges, of automatic-closing type;
Four gauge-cocks;
One sentinel-valve;
One salinometer-pot;
One drain-cock;
One air-cock;
One approved circulating apparatus;
One cock with thread for the attachment of a syringe.

All external fittings will be of composition unless otherwise directed. All fittings will be flanged and through-bolted or attached in other approved manner. All cocks, valves, and pipes will have spigots or nipples passing through the boiler-plates. All internal pipes will be of brass, No. 14 B. W. G., and must touch the





plates nowhere except where they connect with their external fittings. The internal feed and blow-pipes will be expanded in the holes in boiler-shells to fit the nipples on their valves, and they will be supported where necessary in an approved manner. The stems of all valves on boilers are to have outside screw-threads. The internal feed and blow-pipes are to be arranged to come between the corrugations of furnaces.

113. BOILER STOP-VALVES.

There will be a 4½-inch self-closing stop-valve, with horizontal spindle, on each boiler. The valve will be bolted to the front head of each boiler, as shown, there being a spigot beyond the flange long enough to afford a good fastening for the dry-pipe.

114. DRY-PIPES.

There will be in each boiler, as high as possible and properly supported, a 4½-inch brass dry-pipe, No. 14 B. W. G., extending nearly the length of the boiler perforated on its upper side with longitudinal slits, as shown. The valve end of the pipes will be expanded so as to fit the spigots of the stop-valve nozzles, and will be secured to them by four pins. The pipe will be closed at the inner end and have a ½-inch drain-hole in its under side near each end.

115. FEED CHECK-VALVES.

The main and auxiliary check-valves will each be 2 inches in diameter. They will be fixed on the shell at front ends of the boilers, but entirely separate from each other, and will be fitted with internal pipes, the feed-pipes leading above the tubes and pointing downward in the water spaces between the nests of the tubes and between the nests and shell.

The valve-cases will be so made that the bottom of the outlet-nozzle shall be at least ½-inch above the valve-seat. The valves will be assisted in closing by phosphor-bronze spiral springs. These valves will have polished brass bent bar-handles in lieu of hand-wheels.





116. SAFETY-VALVES.

Each boiler will have two 2½-inch spring safety-valves placed as near the front of boiler as possible; the two valves to be in one case. Each valve will have a projecting lip and an adjustable ring for increasing the pressure on the valve when lifted; or an equivalent device for attaining the same result. They will be adjustable for pressure up to the test pressure; the adjusting mechanism to have an index to show the pressure at which the valve is set, and a lock to prevent tampering with the adjustment. The locks on all safety-valves will be alike. The springs will be square in cross-section, of first quality of spring-steel, and will be nickel-plated. They will be of such a length as to allow the valves to lift one-eighth of their diameters when the valves are set at 160 pounds pressure. They will have spherical bearings at ends, or be connected to the compression-plates in such a manner as to insure a proper distribution of pressure. They will be inclosed in cases so arranged that steam will not come in contact with the springs. The spring-cases will be so fitted that the valves can be removed without slacking the springs. The valve-stems will fit loosely in valves to bottom below the level of the seats, and to be so secured that the valves may be turned by a wrench or cross-bar on top of stem. The valves will be guided by wings below and in an approved manner above. The valves will be fitted with mechanism for lifting by hand from main deck and fire-rooms; the mechanism for each pair of valves to be such that the valves will be lifted in succession. All joints in the lifting-gear will be composition bushed. The outlet-nozzle will be in the base casting, so that the joint at the escape-pipe will not have to be broken when taking the valves out. The casings, valves, and spindles will be made of composition. The valve-seats will be of nickel, or equivalent metal of approved kind. A drain-pipe will be attached to each safety-valve casing below the level of the valve-seats, leading to the bilge.





Each safety-valve casing will have an internal pipe leading to the top of the boiler or be connected to the dry-pipe.

117. SENTINAL-VALVES.

Each boiler will have a sentinel-valve at the front end ½ square inch in area. It will have a sliding weight on a notched lever graduated to 170 pounds pressure.

118. BOTTOM BLOW-VALVES.

There will be a 2-inch bottom blow-valve on each boiler, bolted to the shell near the front. The valves will close with the boiler-pressure. An internal pipe will lead from each valve to near the bottom of the boiler.

The valve-casing, valve, hand-wheel, and valve-stem will be made of composition.

119. SURFACE BLOW-VALVES.

There will be a 1½-inch surface blow-valve on each boiler, bolted on or near the front. The valves will close with the boiler-pressure. An internal pipe will lead from each valve to near the water-line in the boiler, and will be fitted with a scum-pan.

The valve-casing, valve, hand-wheel, and valve-stem will be made of composition.

120. BLOW-PIPES.

A 2-inch pipe will connect with the bottom blow-valves and with a sea-valve in the same compartment. This pipe will have a nozzle for the connection of a pipe for pumping out the boilers, as well as 1½-inch nozzles for attachment of pipes from the surface blows. There will be a straightway-valve in the blow-pipe as near the sea-valve as possible. All joints will be flange-joints.

BOILER PUMPING-OUT PIPES.

A 2-inch pipe will connect the blow-pipe with the auxiliary feed-pump, with a screw stop-valve above the floor near the pump.





122. STEAM-GAUGES.

There will be one spring steam-gauge, equal to "Lane's improved," with seamless tubes, on each boiler, with 8½-inch dial, graduated to 255 pounds. Each gauge will have an independant connection with its boiler and be fitted with a three-way cock and a coupling for attachment of a test-gauge.

123. BOILER WATER-GAUGES.

Each boiler will have two glass water-gauges of approved automatic-closing pattern. Each gauge will be placed at the side of the boiler and will have 1½-inch pipes leading to top and to near bottom of boiler, with a valve in each close to boiler. The shut-off and blow-out cocks are each to have at least ½ inch clear opening, and will be packed cocks, with levers and rods for working from fire-room. The glasses will be about 16 inches in exposed length, with the lowest exposed part about 1 inch above the highest heating surface. The glasses will be well protected. A brass index-plate, with letters and arrows cast in relief, will be fixed close to each gauge-glass to show the height of the top of combustion-chamber. The blow-out cocks will have drain-pipes leading to bilge, with union joints.

124. GAUGE-COCKS.

There will be four asbestos-packed gauge-cocks of approved pattern on each boiler, with rods and levers for working from fire-room. Each cock will have an independent attachment to the boiler. They will be spaced about 6 inches vertically, the lowest one being about 4 inches below the highest heating surface. Each set of cocks will have a drip-pan and a drain-pipe leading to bilge.

125. SALINOMETER-POTS.

There will be a salinometer-pot of approved pattern connected to each boiler. They will be placed close to each other in the fire-room where directed.





126. BOILER DRAIN-COCKS.

Each boiler will have a 1-inch drain-cock of approved pattern.

127. BOILER AIR-COCKS.

Each main boiler will have a ½-inch air-cock at its highest part, with a ½-inch copper pipe leading to bilge.

128. CIRCULATING APPARATUS.

There will be fitted to each boiler an approved device for circulating the water in the boiler while raising steam. Each of these will be fitted where directed and have a stop-valve close to boiler. They will take steam from the auxiliary steam-pipe, with stop-valve in fire-room.

129. ZINC BOILER-PROTECTORS.

Each boiler will have rolled-zinc plates 12 x 6 x ½ inch, placed as may be directed. Each plate will be bolted to a wrought-iron strap, which will be clamped to the stays. Each strap will be filed bright where in contact with zinc and stay, each stay being also filed bright at contact point. After being bolted in place the outside of the joints will be made water-tight by paint or approved cement.

130. MAIN FEED-PUMP.

It will be a vertical pump, and will have a capacity of 105 gallons per minute. The water-valves will be metallic, of approved kind. The pump will be so arranged that the packing of the water-pistons can be got at readily. The steam-cylinders must be of sufficient size to work the pump at the required speed to furnish the amount of water above specified. The exhaust-cushion must be adjustable. All working parts will be of wrought-iron or steel.

The main feed-pump will draw water from the feed-tank only and deliver into main feed-pipe only. If the



steam-valve is moved by a supplemental piston, the valve must have a positive motion near the end of the main-piston stroke to prevent piston striking cylinder-head. If a supplemental piston is used, its motion must be horizontal.

131. FEED-WATER HEATER.

There will be an approved feed-water heater in the fire-room, of suitable size, placed where directed.

Plans showing type and arrangement of heater must be submitted to the Bureau of Steam Engineering for approval before work is commenced on it.

132. AUXILIARY FEED-PUMP.

There will be in the engine-room a vertical pump of the same kind and same water capacity as the main feed-pump. It will be connected to draw from the sea, feed-tank, bilge, or boilers at will, and to deliver either into auxiliary feed-pipe, fire-main, or overboard through a Kingston valve.

This pump will have its steam-cylinder adapted for use as a fire-pump with steam of 60 pounds pressure.

In the fire-room there will be a hose connection on fire-main, furnished with a screw straightway-valve.

133. FEED-PUMP PRESSURE-GAUGES.

The main and auxiliary feed-pump will have a spring pressure-gauge, registering from zero to at least 300 pounds per square inch.

134. ASH-HOISTS.

At least one ventilator in the fire-room will have vertical guide-strips of iron on the inside, and be fitted with all the necessary gear for hoisting ashes.

An ash-hoisting engine of approved design will be fitted in the fire-room hatch or such place as may be directed, of sufficient power to hoist 300 pounds from the fire-room floor to the deck in five seconds with steam of 60 pounds pressure.



It will have a reversing-gear, to be worked from the fire-room and from deck, with approved adjustable safety-gear to prevent overwinding and to stop the engine when the ash-bucket reaches the fire-room floor. It will also be fitted with an approved brake to control the drum. The ash-hoist will be fitted with the necessary sheaves, whip, and all appliances necessary for handling ash-buckets.

135. FIRE-ROOM BLOWERS.

There will be two blowers of approved pattern in the fire-room.

These blowers must be capable of supplying to the fires continuously, with ease, sufficient air to maintain the maximum rate of combustion. They will take air from the fire-room in such manner as to thoroughly ventilate it, and deliver into the air-ducts.

The spindle-bearings must be accessible while the blowers are in motion, and will be of anti-friction metal in composition boxes, and, together with their lubricating apparatus, must be thoroughly protected from dust.

136. BLOWER-ENGINES.

Each blower will be driven direct by an inclosed multi-cylinder engine of an improved design, and of sufficient power to run the blower at full speed with steam of 100 pounds boiler-pressure. The engine-valves must be of the slide or piston type.

All working parts must be closed in, but easily accessible for overhauling. The lubrication must be automatic and thorough. The throttle-valve in the steam-pipe of each blowing-engine will be arranged to be worked from the fire-room floor, with suitable index to show how much it may be open. The steam-pipe for each blower will connect with auxiliary steam-pipe.

The shafts of blower-engines will be so fitted that a portable revolution-indicator can be quickly and easily applied without removing any part of the mechanism.





17. AIR-PRESSURE GAUGES.

An approved gauge, equal to those made by the E. P. Gleason Manufacturing Company, will be fitted in the fire-room to show the pressure in each main air-duct.

A portable gauge will also be supplied to the fire-room, with conveniences for connecting it to the furnaces, uptakes, and wherever desired to measure the air-pressure.

These gauges will indicate pressures in "inches of water."

18. FIRE-TOOL RACKS.

Racks will be fitted in each fire-room in convenient places for holding all necessary fire-tools.

19. ASH-DUMPS.

From each ash-hoist, on the upper deck, permanent over head rails, suitably supported, will lead to the ash-chutes on each side of the ship, if directed. Each of these will be fitted with a traveler of approved design, with all necessary appliances for carrying the ash-buckets. At the top of each ash-chute a dumping-hopper of approved design will be fitted, so arranged as to fold up out of the way when not in use. The ash-buckets are to be balanced dump-buckets, with all necessary gear complete. All the ash-hoisting and dumping-gear will be such that the buckets will not have to be lifted by hand.

20. ASH-SPRINKLERS.

A valve for wetting down ashes will be fitted in the fire-room where directed, and will be fitted with all necessary hose, couplings, and nozzles.

21. STEAM TUBE-CLEANERS.

A steam tube-cleaner, of approved design, will be fitted in the uptake room. Steam will be taken from the auxiliary steam-pipe. Sufficient length of steam-hose will be provided to easily reach all the tubes.



142. WORKSHOP MACHINERY.

There will be fitted in the engineer's workshop a double-geared engine-lathe of the best make and of approved pattern. It will be of at least 9 inches swing and 24 inches between centers. It will be fitted with gears for cutting threads from 4 to 40 to the inch, and with four-grade cone-pulleys.

The lathe will be fitted where directed in the engineer's workshop. It will be driven from a counter-shaft with cone-pulleys to suit the machine.

An engine of approved pattern will be provided for driving this lathe.

143. DISTILLING APPARATUS.

The distilling apparatus, placed where directed, will consist of an evaporator and a distiller, with their accessories, having a capacity of 2,000 gallons of potable water per 24 hours at a temperature of not more than 90° F. when the cooling water is taken in at a temperature of 60° F.

The evaporator will be made with shell of plate-steel with welded seams. The heads and flanges will be of cast-iron and the coils of copper, tinned inside and out. It will be felted and lagged, and will be fitted with a safety-valve, steam-gauge, glass water-gauge, gauge-cocks, salinometer-pot, and blow-valve. It will take steam from the auxiliary steam-pipe, and will be fitted with automatic trap and with drain-pipe leading to the feed-tank. The shell of the evaporator will be tested to 50 pounds to the square inch, and the coils and all parts subject to the boiler pressure to 230 pounds per square inch.

The distiller will be made with shell of sheet-brass, flanges and heads of composition, and coils of copper or brass, thoroughly tinned on both sides. The coils of distiller will be divided into at least two parts, each with a separate inlet and outlet-valve.

A filter of approved design will be fitted to the distiller.





There will be efficient means for aerating the distilled water.

There will be a steam-pump of approved pattern, and of a capacity of about 3 gallons per minute at ordinary speed, fitted to draw water from the filter and deliver it into the fresh-water tanks. The cylinders of the pump will be of "light service" proportions, for using steam of 60 pounds pressure. The water end of the pump will contain no copper or lead. A pipe will lead from the atmosphere, above the ship's awnings, to the suction of the pump, with a regulating-valve, so that air can be forced into the tanks with the water. In the water-suction of the pump will be fitted an approved water-meter, made without copper or lead. The discharge-pipes to the fresh-water tanks will lead to the bottoms of the tanks, so that air forced in will rise through the water.

A pump of approved pattern and size will be fitted for feeding the evaporator; also one to circulate the cooling water through the distiller, to draw water from a special sea-valve placed where directed. Also a pump, with metal valves, which can draw the condensed water from the evaporator and deliver it into the auxiliary feed-pipe. This pump will be placed below the level of the evaporator and will take the condensed water from the trap. A connection will be provided between the evaporator and the main condenser, so as to make up the losses.

The water after leaving the distiller will be led forward by a proper pipe with connections for flushing the crew's water-closets, with branches to the officers' water-closets. A by-pass pipe will be provided so that water may pass to the closets when the distiller may be shut off.

The evaporator and distiller will be so fitted that their coils can be easily removed for repairs. There must be no internal detachable joints in the coils of either evaporator or distiller.

144. WASH-WATER TANKS, ETC.

There will be one or more cylindrical wrought-iron tanks, of a combined capacity of 100 gallons, to hold



fresh water for firemen's use. They will be fitted where directed. Each tank will have an overflow-pipe, without valve or cock, leading to the bilge, with the end in plain view from the fire-room; also a drain-pipe with its valve easily reached from the fire-room. Pipes will be led direct from the fresh-water outlet of the distiller for filling these tanks without passing the water through the filters; these pipes to have locked cocks.

There will be an approved hand-pump, which will be connected as follows: to have suction-pipes from the feed-tank suction-pipe and from the tanks above mentioned, and to discharge into these tanks and into the tank in the firemen's wash-room; all pipes fitted with stop-valves close to pump. The pump will have a dead-weight relief-valve set at just sufficient pressure to allow the wash-room tank to be filled.

A cylindrical copper tank, of about 20 gallons capacity, will be fitted in the firemen's wash-room, and connected with the pump above specified. The tank will be supplied with a vent-pipe with a float-valve, which will close the vent when the tank is full. There will be a service-pipe from the tank, with a branch to each wash-basin, and one for filling buckets. Each of these branches will have a self-closing lever-faucet. In the service-pipe, close to the tank, will be a locked cock.

145. MAIN STEAM-PIPES.

A 4½-inch pipe will lead from each main stop-valve. A valve, 4½ inches diameter, in the engine-room, will join the starboard and port main steam-pipes, as shown.

Stop-valves will be placed as shown in drawing, straightway valves being used where shown.

146. AUXILIARY STEAM-PIPES.

There will be an auxiliary steam-pipe extending fore-and-aft, through engine and boiler compartments, and to the windlass, steering, dynamo, and ventilating-fan engines, and to the engineer's workshop. It will connect with the auxiliary stop-valve of each boiler. Stop-valves



will be on the same nozzle as main stop-valves. Branches will extend to all auxiliary machinery herein specified. The pipe will be of sufficient size to supply all auxiliary machinery, including dynamos and ventilating-fans. Wherever pockets necessarily occur, the pipe will be drained and trapped. All branches from the pipe to pumps or engines on a lower level will have the stop-valve for such machinery close to the main pipe, with a spindle for working it from below, so that when the pump or engine is standing idle there will be no opportunity for water to collect in the vertical pipe leading to it, which must be blown out before starting.

147. AUXILIARY EXHAUST-PIPES.

An auxiliary exhaust-pipe, of sufficient size for all steam auxiliary machinery will be fitted and connected to this auxiliary machinery. It will have valves to direct the exhaust-steam into the main condenser, the auxiliary condenser, into either low-pressure cylinder, or into the atmosphere through the escape-pipe at will. At each connection with condensers and escape-pipe the auxiliary exhaust-pipe will be fitted with two stop-valves so as to minimize the chance of an air-leak.

The connection with the escape-pipe will be made below the protective-deck. All exhaust-pipes from engines above the protective-deck leading to the condenser will be fitted with valves below the protective-deck.

148. BLEEDER-PIPES.

A 2½-inch branch from the main steam-pipe of each engine will lead to the condenser, with a stop-valve operated from the working-platform.

149. INTERMEDIATE AND LOW-PRESSURE STEAM-PIPES.

A 1½-inch branch from the main steam-pipe will lead to each intermediate, and a similar pipe to each low-pressure valve-chest, each with a stop-valve.



150. MAIN FEED-PUMP EXHAUST.

The exhaust-pipes from the main feed-pumps, in addition to the connection with the exhaust-main, will be so arranged that the exhaust-steam can be turned into the feed-pump suction instead of into the auxiliary exhaust-pipe—chambers with suitable nozzles for this purpose being fitted in the suction-pipes.

151. ESCAPE-PIPES.

There will be a 7-inch copper escape-pipe abaft the smoke-pipe, extending to the top, finished and secured in an approved manner. This pipe will have branches leading to the safety-valves. It will be fitted with an approved muffler.

The auxiliary exhaust-pipe will also lead into the escape-pipe.

152. MAIN FEED-PIPES.

A seamless-drawn brass pipe, of the full size of the pump-discharge, will lead from the main feed-pump and discharge only into the main feed-pipe, having branches leading to the boilers. Each of these branches will have a straightway-valve, with hand-wheel in a convenient position for regulating the feed. All parts of the pipes will be above the floors, in plain view, and all joints made by flanges screwed on the pipes and bolted together.

153. AUXILIARY FEED-PIPES.

A similar pipe will lead from the auxiliary feed-pump to the auxiliary feed-pipe, having branches to each of the boilers. These branches will be fitted the same as those on the main feed-pipe.

154. FIRE-MAIN.

A pipe will extend fore and aft on the berth-deck, with an approved straightway-valve and fire-plug of Navy standard size where directed in each compartment. This



pipe will be connected with the discharges of the engine-room fire-pump, the engine-room auxiliary pump, and the auxiliary feed-pump. One branch from this main will lead up to the upper deck and be fitted with straightway-valves and fire-plugs. A branch from the main will lead to each magazine passing-room, one to the compartment abaft the engine-rooms, and one to each compartment forward. Each of these branches will be fitted with a straightway-valve and fire-plug, and will be so connected that all of the fire-pumps can work on it. There will be a straightway-valve and fire-plug in an approved position in the engine-room and the fire-room. Drain-pipes will be fitted to drain all parts of the fire-main and branches. A reverse-coupling will be supplied, with adapters to suit the various sizes and threads of fire-hose commonly in use, for the purpose of filling the boilers with fresh water from hose on shore or on boats alongside.

There will be a 1½-inch pipe leading from the auxiliary steam-pipe to each coal-bunker and hold, to be used for extinguishing fire. This pipe will have a valve in it close to auxiliary steam-pipe and another at each coal-bunker or hold bulkhead.

155. PIPES THROUGH WATER-TIGHT BULKHEADS AND DECKS.

They will be made water-tight by stuffing-boxes, flanges, or other approved means.

Pipes must not be led in such manner that the angles or tees of bulkheads have to be cut. Holes through wooden decks, where pipes pass through, will have brass or copper thimbles, made water-tight, extending at least 3 inches above decks.

156. PIPES THROUGH COAL-BUNKERS.

They will be protected by iron casings, made in sections, easily removable for repairs. Pipes must not be led under openings of coal-chutes.



157. DRAIN-PIPES AND TRAPS.

All places where condensed steam can accumulate will be provided with drain-pipes and cocks or valves of ample size, and with approved automatic traps, which will discharge into feed-tank or condensers, or as directed. All traps will have by-pass pipes and valves for convenience of overhauling. The glass water-gauges on all traps under pressure will be of an approved automatic-closing pattern. The lowest parts of all water-pipes and all pump-cylinders and channel-ways will have drain-cocks with pipes where required. The handles of all drain-cocks will point downward when closed.

158. THICKNESS OF PIPES.

The thickness of metal in the principal pipes will be as follows, by B. W. G.:

Steam-pipes above 5 inches bore and less than 7½ inches bore	No. 6
Steam-pipes above 4 inches bore and less than 5 inches bore	No. 9
Steam-pipes of and above 3 inches bore and less than 4 inches bore	No. 11
H. P. exhaust to I. P. cylinder	No. 8
I. P. exhaust to L. P. cylinders	No. 9
L. P. exhaust to condenser	No. 10
Circulating-pump suction and discharge-pipes	No. 11
Bilge-injection pipes	No. 13
Air-pump discharge to feed-tank	No. 14
Feed-pump suction-pipes	No. 13
Feed-pipes	No. 8
Blow-pipes	No. 12
Auxiliary exhaust-pipe	No. 15
Escape-pipe	No. 14
Dry-pipes	No. 14
Connections to fire-main	No. 10
Galvanized wrought-iron bilge-suction pipes	No. 7

All pipes of which the thickness is not given in the above list will be made of approved thickness.



159. AUXILIARY-ENGINE STOP-VALVES.

Each auxiliary engine will have stop-valves in both steam and exhaust-pipes as close to cylinders as possible, except where otherwise specified. Exhaust stop-valves will be straightway where practicable. All pumps, except circulating-pump, will have screw check-valves in both suction and delivery-pipes close to pump-cylinders, so arranged that they may be kept off their seats when desired.

160. MATERIAL AND FITTING OF PIPES.

All pipes, except the lower ends of bilge-suction pipes, will be of copper, unless otherwise specified.

The lower parts of bilge-suction pipes will be of galvanized iron.

All feed and blow-pipes, all bilge-suction pipes, except the lower parts, and all steam-pipes less than 3 inches in diameter, will be seamless-drawn. All copper pipes not seamless-drawn will be brazed. All copper pipes over 3 inches in diameter will have composition flanges riveted on and brazed; all under 3 inches will have flanges or approved composition couplings brazed on. All feed and blow-pipes will have composition flanges. All flanges will be faced and grooved, and joints made with approved material. All composition flanges below the floor-plates will be connected by bolts and nuts of naval brass. All bends in brazed copper pipes will be one gauge thicker than straight parts. All copper pipe T-pieces and fittings will be of composition, except where otherwise directed. Expansion-joints of approved pattern will be fitted where required. Slip-joints, if fitted, will have stop-bolts and flanges. All copper pipes in bilges will be well painted and covered with water-proof canvas, and must not rest in contact with any of the iron or steel work of the vessel.

161. PUMP-CYLINDERS.

All pump-cylinders, together with their valve-boxes and fittings, will be made of composition. Air-chambers



will be fitted on the delivery sides of pumps or in the pipes, as may be directed.

The water-cylinders of all vertical pumps will be so arranged that the pistons can be readily overhauled.

All pumps will have either packed pistons or packed plungers, excepting air-pumps, which will be made as shown.

162. PUMP RELIEF-VALVES.

All feed and fire-pumps will have adjustable spring relief-valves, of approved design, connecting the delivery and suction passages.

163. SEA-VALVES.

There will be in the various compartments sea-valves, as follows:

In the engine-room, a valve of sufficient size to supply water to the fire and bilge-pump, the auxiliary pump, and auxiliary feed-pump; also with a 2-inch nozzle for connection of the water-service pipe. This will be a screw stop-valve, and will have an independent connection to the side of the vessel. Also in the engine-room a double valve-box with a screw non-return valve for the fire and bilge-pump discharge, and a non-return valve for trap-discharge. This valve-box may, if desired, be connected to the outboard nozzle of the main outboard-delivery valve. The main injection and outboard-delivery valves will be as elsewhere specified.

In the boiler compartment there will be the necessary Kingston valve for bottom and surface-blow.

There will also be a sea-suction valve for the distiller circulating-pump, placed where directed.

164. BILGE-STRAINERS.

Each pipe leading from the bilges to the pumps will be fitted with a Macomb, or equivalent, strainer, above the floors.



165. ATTACHMENT OF VALVES TO HULL.

Steel strengthening-rings will be riveted to plating of hull around the openings for all sea-valves. The valve-flanges will be bolted to these rings by naval-brass studs, care being taken not to drill the holes entirely through the rings. A zinc protecting-ring will be fitted in each opening in skin in such a manner as to be easily renewed.

All suction-valves will have strainers over their openings on the outside of the vessel. These strainers will have $\frac{5}{8}$-inch holes with a collective area equal to twice the area of the valve-openings. Strainers must be fastened to valve-casings and not to the plates of the hull.

166. COCKS AND VALVES.

All cocks and valves and their fittings, except as otherwise specified, will be of composition. All hand-wheels will be of finished brass, except as otherwise specified, and will be at least one and one-half times as great in diameter as their valves. All cocks communicating with vacuum spaces will have bottoms of shell cast in and have packed plugs. All cocks over 1 inch in diameter will have packed plugs.

Valves of approved pattern will be supplied wherever necessary to complete the various pipe systems, whether herein specified or not. All valves will be so fitted as to be easily ground in, and be fitted, where required, with grinding-in guides and handles. No conical-faced valve will have a bearing on its seat of more than $\frac{3}{16}$ inch in width. All valve-spindles must turn right-handed to close, and have outside threads when practicable. Cocks and valves may have, where approved, in lieu of wheels or permanent handles, removable box or socket-wrenches, marked and stowed in convenient racks. These handles will be so fitted that they can only be removed when the valves are closed. All cocks and valves underneath the floor-plates will have their wheels or handles above the floor-plates, in easily accessible positions, unless otherwise directed. The sizes of valves as given in these specifications refer to the diameters of the equivalent clear openings.



167. LABELS ON GEAR AND INSTRUMENTS.

All cocks will have engraved brass plates to show their uses and to indicate whether open or shut. All valves except such as may be otherwise directed will have similarly engraved plates to show their uses, or have the same plainly engraved on hand-wheels.

All hand-levers or their quadrants will be similarly marked. Gear for working valves from deck will be marked as elsewhere specified.

All steam stop-valves will have indices to show to what extent they are opened.

All gauges, thermometers, counters, telegraph-dials, speaking-tube annunciators, and revolution-indicators will be suitably engraved to show to what they are connected.

All engraving will be deep and to be filled in with black cement.

168. CLOTHING AND LAGGING.

The main cylinders and valve-chests, after being finally secured in place in the vessel and tested, will be covered with approved incombustible non-conducting material and neatly lagged with black walnut all over, with polished brass bands and round-headed brass screws. The lagging will be made in removable sections over each cylinder, valve-chest, and man-hole cover, the sections to be of such size as to be easily handled, and all parts plainly marked. The lagging elsewhere will be so secured as to be easily removed, replaced, and repaired.

All parts of the condensers except the water-chests at ends will be clothed with approved material, put on in sections so as to be easily removed and replaced.

All steam and exhaust-pipes, the feed-water heater, and all steam-valves will be clothed in an approved manner with a satisfactory non-conducting material, covered with canvas, well painted. The main steam and exhaust-pipes in engine-room will be also covered with black-walnut lagging with brass bands. The canvas



covering of steam-pipes will be secured to bulkheads where the pipes pass through them.

The steam-cylinders of all auxiliary engines will be clothed and lagged the same as main cylinders.

After the boilers are in place and have been tested and painted, they will be covered all over, except where directed, as low as the saddles, with approved incombustible non-conducting material at least 1¼ inches thick. This clothing will be covered on tops, sides, and back heads and on fronts, where required, by galvanized wrought-iron plates about No. 18 B. W. G., flanged not less than 1 inch and bolted together with composition bolts; also secured to boiler-plates at bottom by angle-iron, which will be held in place by ½-inch bolts tapped part way into the boiler-plates, and held off from the boiler-plates elsewhere by suitable distance-pieces.

169. WHISTLES.

An approved polished brass chime steam-whistle, with bell of about 4 inches diameter, will be placed forward of the smoke-pipe well above the level of the awnings, and connected to the auxiliary steam-pipe by a pipe having a stop-valve at its lower end and a working-valve at the upper end. The pipe will have an expansion-joint at lower end.

There will also be a shrieking-whistle of approved pattern and size, and placed where directed.

A drain-pipe with valve will lead from the lowest point of each whistle connection.

170. HOSE AND HOSE-REELS.

A sufficient length of hose will be supplied for the engine-room and the fire-room, to lead to the farthest part of the adjoining coal-bunkers below the protective-deck. The hose for engine-room will be of the best quality rubber-lined linen, and that for fire-room, will be the best quality four-ply rubber engine-hose; all 2½ inches diameter, with standard couplings. Each hose



will be supplied with a rubber hose-pipe with handles. A pair of spanners will be supplied for each hose.

A hose-reel of approved pattern will be fitted in the fire-room and a swinging bracket or similar hose receptacle in the engine-room. Hose-pipes and spanners will be fitted in beckets.

171. SHAFTS THROUGH BULKHEADS.

All shafts passing through water-tight bulkheads will be fitted with stuffing-boxes, each in two parts.

172. FLOORS AND PLATFORMS.

The engine-room, fire-room, uptake-room, and connecting passages, will be floored with wrought-iron plates ¼ inch thick, with neatly matched flat-topped corrugations running fore and aft. The plates will be of convenient size and easily removable, except such as form part of air-ducts in fire-rooms. They will rest on proper ledges of angle or T-iron, and will have drain-holes where necessary. Platforms will be provided for getting at all parts of the main and auxiliary engines and boilers. These platforms, where placed over moving machinery, will be fitted the same as the lower floors. In other places they will be made of iron rods ⅝ inch square, placed ¾ inch apart.

173. LADDERS.

Ladders will be fitted wherever necessary for reaching the engine-room and fire-room from deck, and for reaching the various platforms, passages, and parts of machinery. The engine-room ladder will be made with plate-iron sides and light cast-iron treads with corrugated tops. The fire-room ladder will be made with plate sides and double square-bar treads.

All ladders will be so fitted as to be easily removable where required, and will be jointed and hinged, with necessary fastenings and gear, where they have to be moved when closing hatches. Light iron ladders will



be fitted to and through one ventilator in the engine-room as means of egress when the battle-hatches are closed.

Gear will be provided for quickly opening the battle-hatches over the fire-room ladder, this gear to be worked from fire-room.

174. HAND-RAILS.

Hand-rails, easily removable where required, will be fitted to all ladders and platforms, around moving parts of machinery, and along bulkheads and passage-ways. The hand-rails and stanchions will be made of deoxidized bronze, or of approved equivalent metal which will not easily tarnish, and will be polished all over. The lower ends of stanchions will pass through floor-plates with nuts underneath.

175. GEAR FOR WORKING VALVES FROM DECK.

The safety-valves, boiler stop-valves, and engine-room stop-valves, as elsewhere specified, will have suitable gear for working them from the main deck.

The rods of the gear will be guided and supported on deck by cast composition standards, left rough and painted. Each rod will have a hand-wheel at least 3 feet above the deck. The main stop-valve hand-wheels will be 10 inches in diameter, each to be fitted with an approved lock and key; all locks and keys to be alike. The auxiliary stop-valves will be similarly fitted with 8-inch hand-wheels. The wheels will be of brass, polished, and will have their rims connected with the hubs by plain disks without holes in them. Or in lieu of hand-wheels, if directed, polished brass bar-handles will be fitted to squares on the turning-rods, and will be stowed in beckets on bulkheads. The tops of rods will be protected by brass caps. All hand-wheels will be engraved with name; or cast-brass label-plates with polished raised letters will be fixed to adjoining bulkheads.

176. LIFTING-GEAR.

Efficient lifting-gear, consisting of traveler-bars and pulleys, deck-beam clamps, turn-buckles, shackles, hooks,





eye-bolts, and as may be directed, will be fitted wherever required for lifting parts of the machinery for overhauling and repairing.

Holes will be tapped in all the principal movable parts of machinery for this purpose.

177. OIL-TANKS.

Oil-tanks, of 200 gallons total capacity, divided as directed, will be fitted where directed, with facilities for filling from deck. They will be made of wrought-iron not less than ⅛ inch thick, and will each have a glass gauge, a man-hole and cover near the top, and a locked cock for drawing oil. In the engine-room there will be fitted two copper oil-tanks of 10 gallons each and two of 4 gallons each, and in the boiler compartment one of 3 gallons, all with lock-cocks. All oil-tanks will be fitted with drip-pans.

Each of the larger oil-tanks will have a hand-pump and pipes for filling the smaller tanks.

One iron tallow-tank, with hinged cover, will be fitted where directed.

After the plates of these iron tanks are flanged, and before riveting, they will be galvanized.

178. VENTILATORS.

Ventilators 24 inches internal diameter, with cowls well above the awnings, will be fitted as may be directed.

The ventilators will be of wrought-iron, No. 11 B. W. G., butted and single-strapped and flush-riveted. The cowls will be movable, of No. 12 B. W. G. copper, not planished, and at least 48 inches in greatest diameter. The base-rings of cowls will be of composition, finished on working parts but left unfinished on the outside. All cowls will be fitted with gear for turning them from engine and fire-room, the gear to be of composition except the spindles, which will be of wrought-iron. Brass hand-wheels or T-handles will be fitted to spindles in engine and fire-room.

A ventilator in fire-room will be fitted for hoisting ashes, as is elsewhere specified.



179. TOOLS.

The following tools will be furnished in addition to those elsewhere specified:

One set of wrenches complete for each engine and the fire-room, to be fitted for all nuts in their respective compartments, plainly marked with sizes, and fitted in iron racks of approved pattern. The wrenches for nuts of bolts less than one inch in diameter will be finished, and for all over two inches in diameter will be box-wrenches, where such can be used. Socket-wrenches will be furnished when required. Open-end wrenches will be of steel or wrought-iron with case-hardened jaws, all others of wrought-iron or cast-steel;

One pair of taps, on rod, for each size of tube, for tapping front and back tube-sheets, heads and front plates of combustion-chambers of boilers at one operation. This will be a duplicate of that used in originally tapping the sheets, and be so packed as to be perfectly protected from injury;

A fixed trammel for setting the main valves without removing the covers, the valve-stems to be properly marked for this purpose;

Fixed trammels or gauges for aligning crank-shafts, brass pins being let into pillow-blocks and center-marked for this purpose;

Two complete sets of fire-tools for the fire-room;

Two coal and two ash-buckets for the fire-room;

All trammels and gauges will have protecting cases. All tools will be conveniently stowed.

180. DUPLICATE PIECES.

The following duplicate pieces, in addition to others specified, will be furnished, fitted, and ready for use, viz:

One set of valves for each pump;

One valve-seat, with guards and bolts complete, for air-pumps;

One-half set of follower-bolts and nuts for each steam-piston, and one set for each air-pump piston;

One-half set of springs for each steam-piston;



Two bottom brasses and two top brasses for crank-shaft bearings;

Two crown brasses and two butt brasses for crank-pins;

Two cap and two butt brasses for cross-head journals;

Brasses complete for two cross-heads;

One section of crank-shaft, to be fitted in place, and delivered at such naval station in the United States as may be directed, to be left in store;

A full set of blades for each propeller, fitted to propeller-bosses. These blades will be of such pattern as may be directed after the trial of the vessel;

One complete set of brasses for each main engine valve-gear;

One complete set of brasses for circulating-pump engine, air-pump engine, main feed-pump, fire-pump, and each blowing-engine;

Four spare cup-leathers for each one fitted in hydraulic gear;

One piston-rod for each piston of pump in fire-room;

One feed-check valve complete;

One bottom-blow valve complete;

One surface-blow valve complete;

One complete set of metallic packing for each stuffing-box;

A spare hose and nozzle for each steam tube-cleaner;

One-eighth of a complete set of grate-bars and bearers for all furnaces, and one pattern for each casting;

One dead-plate and one pattern for same;

One ash-pit damper, with gear complete;

One ash-pit door;

Twenty-five stay-tubes for boilers, threaded to fit threads in tube-sheets, with ends wrapped in canvas;

Twenty-five ordinary boiler-tubes, swelled at one end and annealed, ready for use;

One duplicate for each 3-inch stay-tube used;

Twenty-five condenser-tubes, packed in boxes;

Twenty-five condenser-tube glands;

One spare spring for each safety-valve and relief-valve;

One spare basket for each Macomb bilge-strainer;

Two zinc protecting-rings for each sea-valve opening;



One set of coils for evaporator.

Wherever duplicate pieces are furnished for one of two or more pieces of machinery of the same size, they will be made strictly interchangeable.

All finished duplicate pieces not of brass, except as otherwise specified, will be painted with three coats of white lead and oil and well lashed in tarred canvas, with the name painted on outside. Brass pieces will be marked or stamped. All pieces will be stowed in an approved manner.

All boiler-tubes will be securely stowed in racks, or as directed.

181. MATERIALS AND WORKMANSHIP.

All castings must be sound and true to form, and before being painted must be well cleaned of sand and scale, and all fins and roughness removed.

No imperfect casting or unsound forging will be used if the defect affects the strength or to a marked degree its sightliness.

All nuts on rough castings will fit facings raised above the surface, except where otherwise directed. All flanges of castings will be faced, and those coupled together will have their edges made fair with each other. The faces of all circular flanges will be grooved.

All bolt-holes in permanently fixed parts will be reamed or drilled fair and true in place, and the bodies of bolts finished to fit them snugly.

All pipes beneath floor-plates will be connected by forged bolts and nuts of naval brass.

All brasses will fit loosely between collars of shafting.

All brasses or journals will be properly channeled for the distribution of oil.

Packing for stuffing-boxes will be such as may be approved.

All small pins of working parts will be well case-hardened.

All steel joint-pins of valve-gear will be hardened and ground to true cylindrical surfaces.





All materials used in the construction of the machinery will be of the best quality. The iron castings will be made of the best pig-iron, not scrap, except where otherwise directed.

Composition castings will be made of new materials. The various compositions will be by weight as follows:

For all journal-boxes and guide-gibs, where not otherwise specified—

Copper 6, tin 1, and zinc ¼ parts.

Naval brass—

Copper 62, tin 1, and zinc 37 per cent.

For composition not otherwise specified—

Copper 88, tin 10, and zinc 2 per cent.

Muntz metal will be of the best commercial quality.

Anti-friction metal will be of approved kind.

Ornamental brass fittings will be of good, uniform color.

All castings will be increased in thickness around core-holes. Core-holes will be tapped and core-plugs screwed in and locked, except where bolted covers are used, or where it may be directed that the holes be left open.

All steel forgings will be without welds and free from laminations.

All flanges, collars, and offsets will have well-rounded fillets.

All boiler-plates, stays, and tubes will be well cleaned of mill-scale by pickling or other approved means.

All flanged parts of boilers will be annealed, after flanging, in an approved manner.

India-rubber valves will be of approved kind, of best commercial quality.

All bolts for securing the boiler attachments will, where possible, be screwed through the boiler-plates, with heads inside.

All work will be in every respect of the first quality and executed in a workmanlike and substantial manner.

Any portion of the work, whether partially or entirely completed, found defective, must be removed and satisfactorily replaced without extra charge.



182. TESTS OF MATERIAL.

All steel used in the construction of the boilers, and all steel forgings and castings, will be tested in accordance with rules prescribed by the Navy Department.

All boiler and condenser-tubes will be tested to 300 pounds pressure per square inch, applied internally, before being put in place.

India-rubber valves, taken at random, must stand a dry-heat test of 270° F. for one hour, and a moist-heat test of 320° F. for three hours, without injury.

183. TESTS OF BOILERS AND MACHINERY.

Before the boilers are painted or placed in the vessel they will be tested under a pressure of 250 pounds to the square inch above atmospheric pressure. This pressure will be obtained by the application of heat to water within the boilers, the water filling the boilers quite full.

The steam-pipes and valves, the auxiliary engines, and all fittings and connections subjected to the boiler-pressure will be tested by water-pressure to 250 pounds to the square inch.

The high-pressure cylinders, jackets, and valve-chests will be tested by water-pressure to 240 pounds to the square inch, the intermediate-pressure cylinders and connections to 150 pounds, and the low-pressure to 100 pounds. The exhaust side of the low-pressure valve-chests will be tested to 30 pounds. The condensers will be tested to 30 pounds.

The pumps, valve-boxes, and air-vessels of the feed, fire, and bilge-pumps will be tested to 300 pounds per square inch. The cylinders and condensers will be tested before being placed on board, and must be so placed that all parts may be accessible for examination by the inspector during the tests. All parts will also be tested after being secured on board. No lagging or covering is to be on the cylinders or condensers during the tests.

184. PAINTING.

After a satisfactory test, the boilers will be painted on the outside with two coats of brown zinc and oil, and



when in place the fronts will be painted with one coat of black paint.

All engine-work, not finished, will be primed with two coats of brown zinc and oil, and when placed in position on board the vessel will be painted with two coats of paint of approved color. The shafting, when in place, will be painted with two coats of red lead and oil and two coats of black paint.

The smoke-pipe will be thoroughly painted before and after erection on board. The ventilators and cowls will be painted similarly to the smoke-pipe, except the interiors of the cowls, which will be painted vermilion.

All pipes will be painted in accordance with a schedule to be hereafter furnished.

185. PRELIMINARY TESTS AND TRIALS.

Steam will not be raised in the boilers until after the water-test on board, unless desired for drying or testing joints, for which purpose the pressure must not exceed 10 pounds per square inch.

After testing, steam will be raised in the boilers whenever required to test the connections and workings of all parts of main and auxiliary engines. All expense of such preliminary tests will be borne by the contractor.

186. SUPERINTENDING ENGINEER'S OFFICE.

A suitable office and a suitable draughting-room, properly furnished and heated, will be furnished by the contractor for the use of the superintending naval engineer and his assistants.

187. RECORD OF WEIGHTS.

All finished machinery, boilers, and appurtenances thereof, as fitted, and all spare machinery and tools herein specified, will be weighed by the contractor in the presence of the superintending naval engineer or one of his assistants before being placed on board; and no part of the material will be placed on board without being so weighed to the satisfaction of the superintending naval engineer.





188. WORKING DRAWINGS.

All drawings necessary for the prosecution of the work must be prepared by and at the expense of the contractor. Those which are developments of the drawings furnished and of these specifications will be subject to the approval of the superintending naval engineer before the material is ordered or the work commenced.

In the drawings furnished, figured dimensions, where given, will be followed, and not scale dimensions, unless otherwise directed. All discrepancies discovered in drawings, or between drawings and specifications, will be referred to the Bureau of Steam Engineering.

A copy of each working drawing will be furnished to the superintending naval engineer before the work shown by the drawing is commenced. A copy of each drawing accompanying orders for steel castings or forgings will also be supplied when the work is ordered.

189. DRAWINGS OF COMPLETED MACHINERY.

The contractor will make and furnish to the Bureau of Steam Engineering, through the superintending naval engineer, a complete set of drawings of the boilers, machinery, and appurtenances as actually completed, including plans of the same as fitted on board the vessel. These drawings will include every piece of machinery, both in whole and in part, and will be in such detail as would enable the entire machinery to be duplicated without additional drawings. No sheet will contain drawings of more than one part of the machinery, except those intimately connected with each other. The detail drawing of each part of machinery will be furnished within one month after the completion of the part, without waiting for its incorporation into the machine as a whole. Detail drawings will be made to a scale of not less than one and one-half inches to the foot. General plans of the machinery in place in the vessel will be made to a scale of one-quarter of an inch to the foot. Pipe plans will be made to a scale of not less than three-eighths of an inch to the foot. The pipe plans will be



divided into at least two parts—one showing steam and exhaust-pipes and the other showing all other pipes. The pipe plans will be colored, in accordance with a schedule to be furnished, to indicate the purpose which the pipes are intended to serve, and accompanied by an explanatory index.

All drawings will be made on the best quality of tracing-cloth, all sheets being, as far as possible, multiples or sub-multiples of "double-elephant" size.

Detail drawings will be hatched, where in section, in accordance with a schedule to be furnished, to show the various metals employed.

190. CHANGES IN PLANS AND SPECIFICATIONS.

The contractor will make no changes in the plans or specifications without the approval of the Navy Department. In case it is thought advisable to make changes, the contractor will make application by letter to the Bureau of Steam Engineering, through the superintending naval engineer, stating the nature of the change, accompanied by complete plans and specifications of the proposed change, together with a statement of his estimate of the amount of increase or decrease in cost.

191. INSPECTION.

The work of construction of the boilers, machinery, and appurtenances shall be at all times open to inspection by officers appointed for such purpose by the Navy Department. Every facility will be afforded such inspectors for the prosecution of their work. All handling of material necessary for purposes of inspection will be done at the expense of the contractor. All test specimens necessary for the determination of the strength of material used will be prepared and tested at the expense of the contractor. The contractor will furnish the superintending naval engineer with a weekly list of the number of men of each class employed upon the work, together with a statement of the number of hours' labor in each class.



